the roofs blown off. Nearly every building suffered more or less damage.

From all information obtainable the storm seems to have been confined to the southern part of the peninsula, being very serious in the San José del Cabo district, and probably reached some distance into the sea. It extended very little northeast or west of La Paz. The effects of the storm in Mazatlan, Altata, and Guyamas were not so noticeable, but a heavy southwest swell was felt. At Santa Rosalia very little wind was registered, and it never reached the velocity of a storm. A heavy southeast swell continued for two days without doing any material damage, except the washing out of a piece of track of the Boleo Co. Shipping schedules in this part of the gulf were somewhat deranged. It was thought that the 11 German sailing vessels anchored off Santa Rosalia might suffer damage, but they withstood the running sea in splendid condition.

The total damage wrought in the storm area, not counting the ships lost at sea, is estimated at about half a million pesos.

So far as existing records show, violent storms are of rare occurrence in this part of the North Pacific Ocean. It is, therefore, interesting to note in connection with the present one that it occurred in a year of few hurricanes in West Indian waters, some hundreds of miles to the eastward. It may be noted also that in 1918 precipitation set in on the Pacific coast at a very early date, almost unprecedented rainfall occurring in northern California during the period from September 12 to 15 or at about the time the storm off the Mexican coast must have had its inception.

THE COLD WINTER OF 1917–18.

By PRESTON C. DAY.

[Dated: Washington, D. C., Jan. 20, 1919.]

CONTENTS.

The severity of the weather experienced during December and January of the winter of 1917–18 over the greater part of the United States east of the Rocky Mountains, and also over much of Canada and Alaska during the early part of the period, was so unusual as to the length of time the low temperatures persisted, the great area involved, and the degree of cold maintained, that some discussion of the contributing factors, and comparison with similar occurrences of previous years, seems desirable.

WEATHER PRECEDING DECEMBER, 1917.

Reviewing somewhat the weather for a few months prior to December, 1917, we find that September was a cold month over much of the eastern half of the United States; but in Canada, particularly in the Northwest Provinces, the month was distinctly warm. October was a cold month in all portions of the United States from the Rocky Mountains eastward. In fact, it partook largely of the characteristics of a winter month in the great central valleys. Freezing weather occurred throughout nearly all portions of the country; the earliest frosts of record were reported from points in the Southwest: and unusually heavy snows occurred near the end of the month in the Lake region and northern Appalachian districts. (1), (4–7). Over the whole of Canada, except the extreme eastern and western portions, the month was likewise cold, although the departures of the mean temperature from normal were not generally so large as in the adjoining portions of the United States.

Cold weather continued during much of November over the eastern districts of the United States and Canada; but from the Mississippi River westward and in central and western Canada the month was, as a whole, much warmer than the average. In fact, it was among the warmest of record for November in the northern Great Plains and the adjoining portions of the Canadian Northwest, and warmer in portions of the Dakotas by several degrees than the preceding month of October.

In view of the marked warmth of November over certain districts, immediately following a month or more of generally low temperatures, and preceding a long period of intense cold, an unusual opportunity is afforded for a detailed survey of the atmospheric pressure, the resulting movement of the Highs and Lows, and the surface drift of the winds during that month as well as succeeding winter months, to determine an explanation of the causes immediately responsible for such marked variations in weather conditions over the United States.

Barometric data for the United States and the districts to the northward, including the far northwestern stations of Canada and the special stations maintained in Alaska, as well as reports from ships plying the North Pacific, have been carefully charted for the months November, 1917, to February, 1918, inclusive. These charts show the daily departures of the actual surface pressure from the normal, and indicate the deflection of the surface winds from their usual courses, and the locations of the larger and more permanent areas of high and low pressure, as well as the movements of the smaller cyclones and anticyclones thrown off from these great centers of atmospheric action. The departures shown on the charts are based on 8 a. m. (75th Meridian time) observations except for a few stations in the far northern districts of Canada, the stations in Alaska, and the vessel reports from the North Pacific, where the observations were made at various hours. However, during the winter season in these northern regions the normal diurnal fluctuations in pressure are slight, and probably no material error has arisen from the use of these data without correction.

An examination of these charts discloses the dominating factor controlling the November weather over the United States to have been a persistent area of high pressure over the interior portions of the United States, and the adjoining districts of the Canadian Northwest. Over the coast districts of Alaska and British Columbia and the nearby portions of the North Pacific Ocean, on the contrary, low pressure was equally persistent.

November is usually a month of considerable storm activity, particularly over regions adjacent to the higher latitudes of the North Pacific, and low-pressure areas frequently move off the ocean into the Pacific States or British Columbia, whence they pursue eastward or southeastward courses toward the Atlantic coast. Likewise high-pressure areas usually move into the Northwestern States from the British Provinces during the month.

It is a noteworthy fact that, associated with the ridge of high pressure over the northwestern States in November, 1917, not a single storm entered the United States directly from the Pacific. About the 18th, however, a deep depression from the North Pacific advanced into central Alaska and during the following few days it rapidly skirted the high-pressure area overlying the western Canadian Provinces, and entered the United States from the Hudson Bay region, appearing about the 21st as a severe storm over the Lake region, with a marked reduction in pressure over all eastern portions of the United States and Canada. This was followed by high pressure, and the first decided change to colder weather during the month over the eastern districts was inaugurated. To the westward, however, warm weather was maintained until near the close of the month, when a rapid disintegration of the dominating high area ended the stagnant condition that had persisted so long.

While the eastward drift of low-pressure areas from the North Pacific was apparently blocked, it was also unusual that not a single strong high-pressure area entered the western United States during the month. Such changes in pressure as appeared in the movements of the high areas over the United States were apparently developed from within, or reached the eastern districts by routes lying north of the Great Lakes; and it was not till the close of the month that this condition gave way. The final result of this long-standing area of high pressure was a more or less permanent reversal in the direction of the prevailing surface winds over the northwestern States and the adjacent portions of Canada, so that the usual frequent drift from the north was replaced by a general movement from the south that carried the warmth of the middle portions of the United States far to the northward.

CHARTS I to IV illustrate the persistence with which this general type of pressure distribution continued. Modifications of the general type occurred at intervals, but throughout the month the main features—high pressure over the United States, low pressure in northern regions, and the absence of well-marked cyclonic or anticyclonic movements—were dominant. This condition favored a more or less stagnant state of the atmosphere, clear skies, southerly winds over the central and northern districts, and high day temperatures.

THE WEATHER OF DECEMBER, 1917.

With the closing days of November there was a rapid fall in pressure over interior Alaska and the British Northwest, which quickly overspread the United States, and effectually dissipated the stagnant condition of high pressure that had existed so persistently during November. At the same time, pressure far above the normal, with intense cold, entered the Arctic portions of Alaska, and by the first of December the whole of that Territory, the adjacent portions of the North Pacific Ocean, and the greater part of British America as far east as Hudson Bay, were in the grip of one of the severest cold waves of recent years. High pressure and intense cold continued with slight intermissions throughout the entire month of December over the greater part of Alaska and the British Northwest. A few days after their first appearance these conditions had extended southward to the United States, where the month as a whole was one of the coldest of record over a large area east of the Rocky Mountains.

EXTREME COLD IN THE YUKON REGION.

Beginning on December 1, the temperature at Eagle, Alaska, fell to about −50° F. and later to −63° F., and during the entire month it did not rise above −25° F. The average of the daily maximum temperatures for the month was −40° F. and the average minimum was −52° F. Some conception of the degree of cold experienced in that territory during this period is afforded by comparing the monthly mean temperature of December, 1917, at Eagle, with the means for the same month of other years. The mean temperature for December, 1917, was −46° F.; the lowest previous mean for the same month, in a more or less complete record covering the past 30 years, is −23° F. December, 1917, therefore, averaged 23 degrees F. per day colder than the coldest previous December of which there is record. It is probably safe to say that no such depression in temperature from previous low records has been experienced in the known history of that Territory. The normal temperature for December at Eagle is about −12° F.; the depression of the mean for December, 1917, below the normal for the month was therefore about 34 degrees F., a record which, likewise, has probably not been exceeded in Alaska.

At Fort Yukon, on the Arctic Circle, near the international boundary between Alaska and Canada, the average

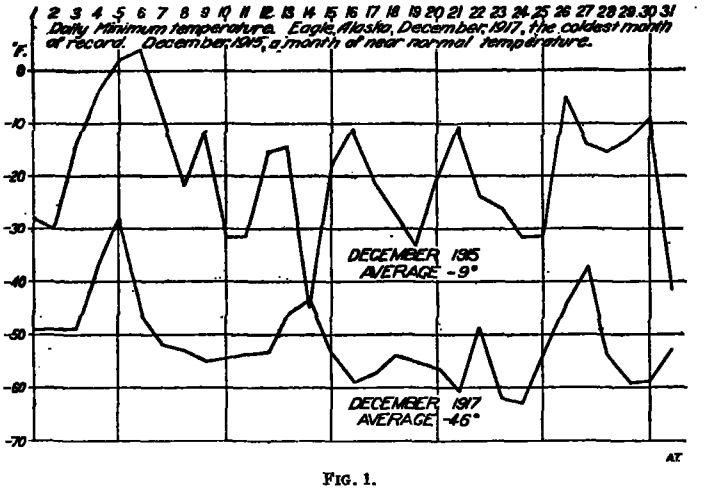

FIG. 1.

minimum temperature was −58° F., about 6 degrees F. lower than at Eagle. The lowest recorded was −67° F., and on no day during the whole month did the minimum temperature rise above −45° F. A note on the report from that station reads as follows, "White men who have been years in the country, and Indians, say they have never known such continued cold weather."

At Dawson, in the British Yukon, the month was by far the coldest ever known. The average of the daily maximum temperatures was −49° F., and of the daily minimum −54° F.; the monthly mean, −51° F., was 29 degrees F. lower than the lowest mean of any previous December and nearly 40 degrees F. below the average. The highest temperature observed during the month was −40° F. and the lowest −63° F.

The persistence and degree of the cold experienced in those far northern regions during December, 1917, is well illustrated by the diagrams herewith (see Figs. 1 and 2) showing the daily fluctuations in the minimum temperature at a few points for that month as compared with a month having about the normal temperature. Figures 1 and 2 show the daily fluctuations of the minimum temperature at Eagle and Dawson for December, 1917, as compared with like records for years having about the normal temperature. Similar values for Fort Yukon, Alaska, December, 1917, are also shown on Figure 2.

At Eagle, the month, while cold throughout, nevertheless, had periods of somewhat moderate temperature,

as shown by the diagram, the range for the month being about 40 degrees, the temperatures fluctuating with the rise and fall in pressure. At Dawson, however, the cold was persistent, the range for the month being only slightly more than one-half that at Eagle.

Figure 3 shows the daily fluctuations of the atmospheric pressure at Eagle for December, 1917, and for the

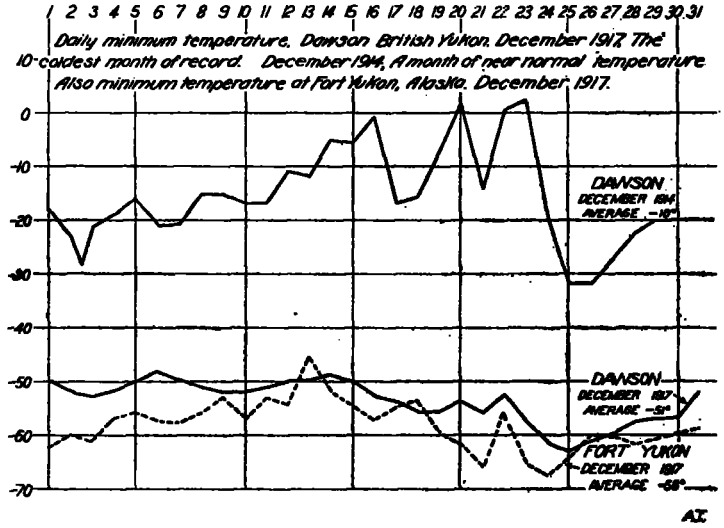

FIG. 2.

same month in 1915, which had temperatures near the normal. This diagram illustrates the degree to which the pressure for the cold December was maintained above that usually experienced.

A fall in pressure of nearly 1 inch at Eagle from the 12th to 15th was accompanied by a rise in temperature of nearly 20 degrees F., while at Dawson a somewhat greater fall in pressure produced practically no change in tem-

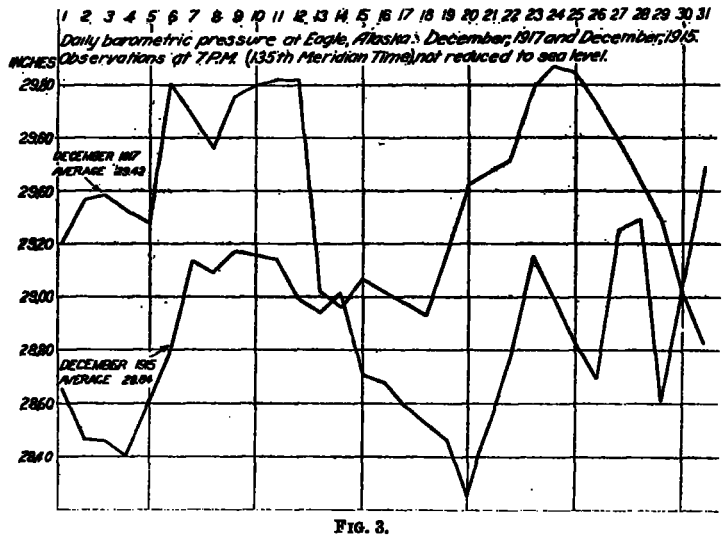

FIG. 3.

perature. At Eagle, however, there was a change in the direction of the wind from northwest to southeast during the period, whereas at Dawson no change in the direction was observed.

While the persistence of the low temperature at Dawson despite marked changes in pressure is somewhat unusual, the general correctness of the record is fully established by the similar report from Fort Yukon, as is shown in Figure 2.[1]

[1] Apparently the cold air in the upper Yukon Valley could not be moved by the changes in winds which undoubtedly occurred in the warmer air a slight distance above the surface.—*C. F. B.*

WEATHER OF EARLY DECEMBER IN THE EASTERN UNITED STATES.

The high-pressure condition was particularly pronounced during the period December 3 to 13 from Alaska south to the western districts of the United States, extending later into the eastern and southeastern districts, where high pressure continued until about the 20th, and again from about the 21st to near the end of the month. The extent of these great high-pressure areas is well illustrated by the accompanying charts, which show their distribution on several dates and combinations of dates during the above periods. (See CHARTS V–X, and XII.)

From this great area of high barometric pressure with its phenomenally low temperature, there broke off a series of anticyclones that moved southeastward over the British Northwest and into the United States. CHART V, December 5, shows the first great southward projection of the high pressure that had been developing in Alaska since the beginning of the month. At this time, the temperature had fallen to nearly −20° F. in North Dakota. However, the general warmth previously existing, and the absence of any snow-cover, so modified the cold of this anticyclone that over most of the country east of the Rockies the temperatures were reduced only to near the normal for the season. In the Rocky Mountain region it is apparent that while the pressure had risen, the cold air moving southward near the mountains was confined to the lower levels and did not extend to the higher elevations of the mountains, although farther east, over the Plains region, the upper air observations indicate that it did extend to rather high altitudes. (2).

About the 7th, a strong high pressure area moved southeastward in the wake of a heavy snowstorm, bringing during the following few days the coldest weather of the season to date into the Gulf and south Atlantic States. The southward movement of the cold air accompanying this high area was greatly augmented by the presence of an area of low pressure over the Gulf States at the same time.

CHART VI, December 10, shows a further development of high pressure over the northern districts and a marked projection of it into the southern portions of the United States. This distribution clearly illustrates the penetration of the cold northerly winds into the Great Plains and Mississippi Valley. The line of zero temperature at that time extended into Oklahoma and east to the Appalachians.

By the 12th, before temperatures in the West had approached normal conditions again, a new southward extension of the great northern anticyclone became apparent along the northern borders of the United States, and temperatures in North Dakota and Montana fell to −20° F. or lower. This cold wave advanced rapidly into the central valleys and temperatures from −20° F. to −30° F, were experienced as far south as Iowa and Nebraska. Immediately in front of this high area severe storm conditions developed, and during the 13th and 14th heavy snow with high winds prevailed from the Lake region to New England, followed by marked cold within the succeeding few days, the temperature falling to nearly −30° F. in portions of New England.

While these adverse weather conditions were being experienced in the East, a great barometric depression was forming in the North Pacific west of British Columbia and southern Alaska. During the 14th and 15th (see CHART VII, Dec. 15), this depression increased greatly in magnitude, and gradually extended inland over the British Northwest as far eastward as Hudson Bay; but high pressure to eastward seems to have blocked effectively its further progress, and it gradually dissipated.

Conditions were still favorable for continued cold northerly winds in the Eastern States and the Maritime Provinces, but southerly winds had set in from the Mississippi River westward and in portions of the Canadian Northwest. Temperatures in the cold western districts of the United States responded promptly to the change in air movement, particularly in the Missouri Valley and the adjacent portions of Canada, where the rise about the 15th–16th amounted to 20 to 40 degrees F. within 24 hours. With the type of pressure distribution indicated by CHART VII, a period of more moderate temperatures prevailed in the central districts of the United States, continuing till about the end of the second decade, when high pressure again became dominant in the far north.

WEATHER OF THE LATTER HALF OF DECEMBER.

High pressure and severe cold still continued over northern Alaska and the Behring Sea region, and gradually moved southeastward during the closing days of the second decade, so that at the beginning of the third decade of the month high pressure had again become firmly fixed over Alaska, the British Northwest, and the adjacent portions of the North Pacific, and a second period of extreme cold, somewhat more intense than the first, had set in over those districts. By the 24th the pressure had risen to more than 1 inch above normal at points in Alaska; and the southern extension of the high area had advanced into the northern portions of the United States between the Great Lakes and the Rocky Mountains with temperature falls approximating 50° F. An eastward moving barometric depression extending from Texas to the Great Lakes accompanied the rapid southward advance of the high pressure area; and by the morning of the 25th nearly the whole of the North American continent was under unusually high pressure. CHART VIII, December 25, illustrates the reestablishment of the pressure type prevalent during the first half of the month, as indicated by CHART VI, previously discussed. A marked fall in temperature had occurred over the northern districts of the United States and during the following day the cold extended to the Gulf and Atlantic coast districts. At Eagle, Alaska, the pressure had remained about 1 inch above normal, but the center of the high area gradually drifted southward, and during the 28th and 29th entered the northern portions of the United States between the Great Lakes and the Rocky Mountains, with barometer readings, reduced to sea level, above 31 inches, about 1 inch above the normal. At this time, temperatures ranged from −62° F., on the Arctic Circle in Alaska, to −30° F., or lower, in portions of Iowa and Nebraska, and to freezing on the south Texas coast. This cold wave extended to the eastern portions of the United States and Canada during the following few days, the temperature falling below −40° F. in the heavily snow-covered northern portions of New York and New England, and to freezing in the central portions of the Florida Peninsula. This was one of the severest cold waves of record over the northern portions of the country from the Great Lakes eastward, particularly in New England.

LOW PRESSURE OVER THE NORTH PACIFIC.

While the air pressure over Alaska, western Canada, and most of the United States was far above normal during the last decade of the month, the pressure over the North Pacific, as shown by a few vessel reports from that region, was persistently below normal. The center of the low area seemed to oscillate from day to day; about the 25th, the cyclone covered a wide area with the lowest barometer readings west of California. The depression moved slowly northward, and near the close of the month had increased greatly in magnitude, and apparently covered the entire North Pacific, with the center off the Alaskan coast, where the pressure was more than 1 inch below normal. (See CHART IX, Dec. 31.) The influence of this low area extended into the interior of Alaska, and at the end of the month pressure in that Territory had very generally fallen to about normal, warmer weather had set in, and the period of unprecedented cold that had persisted for a month or more over Alaska and the adjoining portions of the Canadian Northwest, with scarcely an appreciable break, came to an end temporarily, although farther south over Canada and in the eastern two-thirds of the United States, where a heavy snow-cover had been established, cold weather continued.

CAUSES OF THE COLD WEATHER.

CHART X shows the average departure of the surface pressure from the normal during the 10-day period, December 3 to 12, inclusive, and the direction of the dominating winds for the same period. A glance at this chart shows the extent of the high pressure over the regions north of the United States during this period, and, due to the low pressure in the south and east, the favorable conditions thereby created for the unobstructed flow of air from the intensely cold far Northwest into nearly all portions of the United States. An examination of the wind records for the period, in the regions where their true directions were not obscured by topography, shows how persistently they were maintained from cold northerly regions. In the Great Plains the winds were northerly from 40 to 70 per cent of the time, and as far south as San Antonio, Tex., they were from a northerly point 60 per cent of the time.

CHART XI shows the departure from the normal of the average daily mean temperature for the same period, December 3 to 12, inclusive, and illustrates the extent to which the temperature was influenced by the high pressure and the resultant northerly winds.

CHARTS XII and XIII show respectively the departures of the surface values of pressure and temperature from the normal, and CHART XII shows also the direction of the prevailing winds for the entire month of December.

These charts indicate that practically the whole of the North American continent was under the influence of a great area of high barometric pressure with corresponding cold, central north of the Arctic Circle, which doubtless extended into other northern regions, although lack of reports at this time precludes any conclusions as to the extent of the cold area. Particular attention is invited to the direction of the winds as disclosed on CHART XII, which explains at once why cold was so persistent east of the Rocky Mountains and warmth equally so to the west.

Another factor in the cold weather—one not so evident in December as in January—was the unusually extensive and deep snow cover over a large part of the eastern United States during most of the month.(5) This snow surface by favoring rapid cooling of the air at night [2] and

[2] The snow surface at night cools quickly to a low temperature, because it is a good radiator, and is well insulated from the relatively warm ground by the low conductivity of the snow. The radiant energy emitted from the cold surface is much smaller than that from the surface of the bare ground, which under the same atmospheric conditions is always warmer. Prof. W. J. Humphreys has shown (orally) recently that the air above the snow is cooled rapidly not only conduction, and some radiation, to the cold snow surface, but also by the radiation to space. This net radiation space is usually almost balanced by that received from the ground and warmer strata of the atmosphere; but with very little radiation from below, the air some distance above the snow surface is allowed to cool appreciably.—*C. F. B.*

by preventing appreciable heating by day,[3] kept the northerly winds cold. Also, on account of the large amount of heat required to melt the snow, the infrequent southerly winds could not maintain their high temperatures. Figure 4 [4] shows how the extremely cold weather at Cincinnati was associated with a great depth of snow on the ground.

Temperatures as low or lower, and barometric pressures as high, have doubtless existed in the past history of these far northern regions, but no known record appears of their continuation over such a long period as in December, 1917.

Why these abnormalities existed so persistently at this particular time is not disclosed by any terrestrial or solar observations now available, except, perhaps, those of

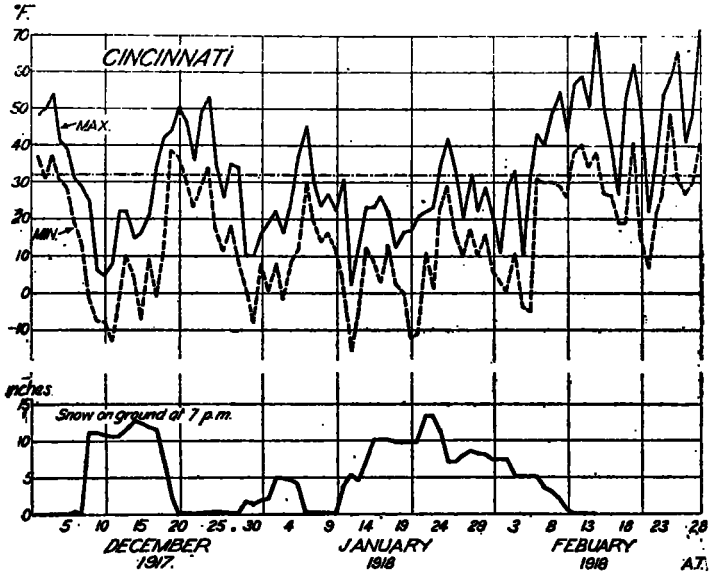

FIG. 4.—Relation between depth of snow on the ground and maximum and minimum air temperatures at the Weather Bureau Station in Cincinnati, Ohio.

sunspot numbers. Prof. H. H. Kimball, in his usual report on solar and sky radiation, in the WEATHER REVIEW of December, 1917, indicates that no appreciable departure from the normal was apparent in the solar output of heat; in fact, at the most northerly station at which such observations were made, Madison, Wis., there was an apparent slight excess of heat received from the sun as compared with the normal. This, however, is accounted for, in part at least, by the unusual dryness of the atmosphere, which favored increased transmission of the solar energy through it.[5]

[3] Dr. C. G. Abbot with his pyranometer has found that a new snow surface reflects 70 per cent of the incident solar and sky radiation, Proc. Nat. Acad. Sci., 1916, 2, p. 335. The remainder can not, of course, raise the temperature of the snow surface above freezing.—*C. F. B.*

[4] Plotted and inserted by C. F. Brooks.

[5] Since these measurements have not been corrected for atmospheric absorption, they are representative only of the intensity of radiation at the earth's surface and could not be expected to give quantitative values of the variations in the solar heat received at the outer limits of the atmosphere. Daily pyrheliometric observations to determine the solar constant were not made, the Smithsonian Institution's solar station not then having been established in Chile. (Cf. Proc. Nat. Acad. Sci., 1918, vol. IV, pt. 8. Reprint, Sci. Am. Suppl., 2241, Dec. 14, 1918, p. 384. Abstract, Science, Dec. 27, 1918, N. S. 48: 635-636. M. W. R., Jan., 1919.) Those observations which were made during 1917, however, Dr. C. G. Abbot says, had a very high average. This is what we would expect, for 1917 seems to have been the year of maximum sunspots in the 11-year cycle.

The 11-year sunspot cycle is a cycle in solar activity, during which the sun radiates the most heat when the spots are most numerous. (Cf. C. G. Abbot: The sun and the weather, Scientific Monthly, 1917, 5: 400-410). Indirectly, then, sunspot relative numbers may be used to obtain approximately the variations in the sun's heat emission. The Wolfer provisional sunspot relative numbers for 1917 and the first half of 1918 are as follows (MONTHLY WEATHER REVIEW, 1918, 46: 403, & Terr. Mag., Mar., 1919):

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1917.....	76.2	71.8	86.6	63.7	112.7	113.8	117.0	143.2	121.9	71.4	90.1	116.8
1918.....	96.3	83.4	72.2	76.5	76.5	64.8	.....	.....	.....	.....	.....	.....

To find a maximum of greater intensity than that of May, 1917, to January, 1918, it is necessary to revert to 1871. Since 1749 there seem to have been only eight Decembers with more sunspots than in December, 1917: 1777, 1787, 1788, 1789, 1836, 1837, 1848, and 1870.

Observations of the upper air strata, as obtained at the Drexel, Nebr., aerological station, do not show more than the normal reduction in temperature with increasing altitude. In fact, during December there was a decided lack of the usual decrease in temperature with elevations above 5,000 feet, the upper levels having slightly higher temperatures than for preceding years. During January, 1918, however, there was evidence that these portions of the atmosphere were markedly colder than usual. A report on the upper air condition during the winter under consideration will be found in Supplement No. 12, MONTHLY WEATHER REVIEW, issued October 26, 1918.

WARMTH OVER THE FAR WESTERN STATES.

No summary of the weather of December, 1917, would be complete without some reference to the abnormal warmth over the States west of the Rocky Mountains, which was as persistent as the cold to the East.

Noting the movements of the highs and lows for December, 1917, as shown by CHARTS II and III in the MONTHLY WEATHER REVIEW for that month, it is seen that no anticyclone entered the northwestern States directly from the Pacific during the month. In fact, of the nine distinct offshoots from the great high-pressure area lying close to the Arctic Circle, practically all entered the United States east of the Missouri River and none pursued the usually frequent course southeastward over the eastern slopes of the Rocky Mountains. As a result of this more easterly advent of the high areas into the States, the accompanying cold winds lost much of their force before reaching the mountains to the westward and did not pass the barriers presented by the high ranges. The districts to the westward therefore continued under the influence of the westerly winds blowing off the comparatively warm waters of the Pacific.

This is well illustrated on CHART X, which shows the prevailing direction of the surface winds during the 10-day period, December 3 to 12 inclusive, and also on CHART XII, showing the prevailing direction of the winds for the entire month. On the plains of Washington and Oregon and over an area extending southward and eastward, the surface wind resultants had strong westerly components. In the higher altitudes these westerly winds were still dominant, as shown by the stations near the Rocky Mountain Divide, and by the records of the upper air observations at Drexel, Nebr., on the Great Plains farther east, where at elevations between 3,000 and 9,000 feet the temperatures were distinctly higher than at the surface.

In addition to the failure of the high areas to influence materially the course of the winds over the districts west of the mountains, an unusually large number of moderate low pressure areas entered British Columbia from the Pacific and remained north of the United States until after crossing the mountains. This favored southerly winds over the far Northwestern States, thereby adding further to the sources of warmth for that region.

For some reason the earth in general is colder when the sun is sending us more heat than when it is radiating less (cf. W. J. Humphreys, Physics of the Air, Journ. Franklin Institute, Sept. 1917, pp. 406-408). At any rate, as we should expect, the atmospheric circulation is most energetic when the earth is receiving the most energy. Changes in the strength of the atmospheric circulation necessarily go hand in hand with changes in the steepness of the barometric gradients. In other words, the great high pressure areas are higher than usual and the low pressure areas lower than usual in times like the winter of 1917-18, when the sun was hotter than usual. Cf. H. Arctowski: Variations in the distribution of atmospheric pressure in North America, Bull. Am. Geogr. Soc., 1910, 42: 270-282.) The general character of the weather at any place seems to be closely dependent on the positions and intensities of the neighboring "centers of actio,n" whose changes seem to be more directly associated with solar changes than is the weather. This is apparently as far as we can go at present. If, as we can not, we could say that the same intensity of sunspot maximum would produce the same features of pressure *distribution*, similar cold winters should have been experienced in the years enumerated. The Decembers of these years were not all cold ones, nor are all unusually cold Decembers included.—*C. F. B.*

SOME OF THE RESULTS ATTENDING THE WEATHER OF DECEMBER, 1917.

At the beginning of December the ground was practically bare of snow over the entire country, as little had fallen during the preceding month, and the heavy snows of the latter part of October had disappeared. On the first two days of December, however, there was considerable snow in northern New York and New England. During the following week heavy snow fell in the Ohio and middle Mississippi Valleys with lighter falls over nearly all northern districts, and by the end of the first decade all central and northern districts from the Rocky Mountains eastward were snow covered, the amounts being especially heavy from Arkansas northeastward to western Pennsylvania. During the following week considerable snow occurred over the Appalachian Mountains and to the eastward and northeastward; and the depth over northern New York and the interior of New England had increased to 2 feet or more.

During the latter part of the second, and the early part of the third, decade of the month there was a general reaction towards higher temperatures, and the large body of snow over the Ohio Valley and adjacent regions disappeared. (see Fig. 4, for example.) There was little snow during the last week of the month, but at its close a rather extensive storm area was central in the Ohio Valley, moving southeastward. During the first day or two of January, 1918, it passed to the Atlantic coast region, leaving a moderate covering of snow from the Carolinas northwestward to the northern Rocky Mountain district.

The heavy snow covering during much of the early part of the month, particularly east of the Mississippi River, where in many districts the fall for the month was in excess of that usually received during the entire year, greatly interfered with farming operations. Plowing was abruptly halted, and the husking of corn proceeded so slowly that at the close of the month a large part of the crop was still in the fields. Heavy snow and extreme cold in the principal coal-mining districts of the east interfered seriously with the production, transportation, and distribution of fuel. At the close of the month much suffering from the severe cold was being experienced, and many important industries were either partially or wholly suspending operations from lack of coal. Heavy ice had formed on most of the important northern rivers, and in the Ohio the conditions were reported as the worst in its history, gorges forming which held for many weeks. (3), (5). While the heavy snow-covering afforded ample protection to winter wheat over most districts during the colder periods of the month, much damage from the severe cold was experienced by the truck crops of the South.

To the westward of the Rocky Mountains and even in a strip just east of the Rockies the mild weather favored all outdoor occupations. Pastures continued green and winter grains made unusual growth. The ground remained unfrozen much of the time, and plowing proceeded without material interruption. In the southern and more western portions of this district the month was abnormally dry. Practically no snow fell during the month, and as November had also been dry the mountains were, in the main, free of snow. This was particularly the case in the Sierra of California, where at the end of the month the deficiency of the snow cover was the greatest ever known, and the possibilities of the failure of the usual water supply were becoming alarming.

THE WEATHER DURING JANUARY, 1918.

With the close of December there was a complete change in the pressure distribution over the districts north of the United States, which ordinarily might have been interpreted as indicating a break in the cold that had persisted so continuously during the preceding month over the central and eastern States. The strong high area that had been maintained during December over the far north had now largely dissipated, and temperatures in Alaska and the British Northwest promptly rose to normal or higher. The change in temperature at Eagle, Alaska, was from −59° F. on December 30 to +7° F. on January 4, a rise of 66° F. The fall in pressure during nearly the same period amounted to an inch or more.[6]

In the United States, however, no such changes were experienced. The remnant of the high-pressure area that had drifted from the far north was moving southeastward near Hudson Bay, and cold northerly winds still swept the eastern districts, temperatures below −30° F. being reported from northern New England.

In the Middle West the first few days of January showed some moderation in temperature, due to southerly winds induced by diminishing pressure in the western Canadian Provinces, which at times were under the influence of a great area of low pressure that covered the whole of the north Pacific Ocean, a condition favorable also for the continuation of unseasonably warm weather in the districts west of the Rocky Mountains.

By the middle of the first decade low pressure had extended to practically all central, eastern, and southern portions of the United States, and there was a general warming up, although the increase in temperature was not in proportion to that usually experienced with such a marked fall in pressure. The snow cover which came with the closing days of December and the beginning of January extended over a wide area as far southward as Tennessee and the Carolinas, and doubtless contributed more than bare ground would have done to the maintenance of low temperatures. Moreover, on account of the unusually low pressure over the southern districts of the United States, such strong gradients were set up as to cause a pronounced flow of cold air from the north into the central and southern portions of the country.

EXTENSIVE BLIZZARD OF JANUARY 11–12.

A further increase in the depth of the snow cover occurred during the 6th to 8th, the fall in the vicinity of Lake Michigan being particularly heavy. At the same time, moderately high pressure with attendant cold weather had again developed over Alaska, the British Northwest, and the North Pacific. This gradually extended into the United States by way of the Rocky Mountains, and brought to portions of that and adjacent regions the coldest weather of the season so far. The movement of this high area southward was greatly augmented by the sudden development near the middle Gulf coast of an extensive low area, which advanced rapidly toward the Lake region, accompanied by rain, sleet, or snow over nearly all districts from the Mississippi River eastward, the snowfall being particularly heavy in the Ohio Valley and portions of the Lake region. The greater portion of the country was now

[6] Without any change of pressure at an elevation of about one mile, such a change 3–4 per cent in the pressure at the surface, could result from a 15–18 per cent change of density (due to a 60–70° rise from such a low temperature) in approximately the first mile of atmosphere above the earth's surface.—*C. F. B.*

under a blanket of snow, the cover east of the Mississippi River being unusually deep. With the movement of the center of low pressure to the Lake region during the 11th and 12th, and the advance of the high into the Mississippi Valley, strong pressure gradients were established and northwest to southwest gales prevailed from the Great Plains to the Appalachian Mountains. Although the pressure at this time had fallen rapidly in northern districts, and was below normal over nearly all parts of the United States, and northward as far as observations extended save over a small area in central Canada, the unusually low pressure attending the storm that moved from the lower Mississippi Valley to the Lakes greatly favored the movement of cold air from the north into the Central Valleys. During the 11th and 12th very strong, cold, north to southwest winds prevailed over the middle portions of the United States, carrying the temperature to nearly −20°F. as far south as Tennessee, and to 20°F. or lower on the Gulf coast and in Northern Florida. (See CHART XIV, Jan. 12.) In the Ohio Valley and adjoining regions January 12 was probably the coldest and most disagreeable day experienced in a century. Southwesterly high winds to strong gales piled the deep snow into huge drifts that seriously blocked traffic, and the extreme cold added greatly to the discomfort of the people already suffering severely from lack of sufficient fuel to meet the requirements of normal winter weather.

Summing up the general weather conditions in Ohio for January 12, Mr. W. H. Alexander, at Columbus, the official in charge of the Weather Bureau climatological work in Ohio, states:

> Unfortunately in this case, as in many others, there are some weather characteristics resulting from the combination of meteorological factors that are not revealed by a mere statement of these factors or elements. For instance, it is scarcely possible to portray adequately the real penetrating character of the winds that blew with gale force all day, causing great suffering and even death to man and beast. It is true that at some stations the temperature has been lower on previous occasions than during this storm; at some the snowfall has been heavier on other occasions; and even higher winds velocities have been recorded, but rarely if ever has there been in this State a combination into which the principal weather elements entered with such force and persistency as during the cold wave of January 12, 1918.

The severe cold attending the blizzard on the 12th drifted east and was followed by a quick but temporary return to normal winter weather. At this time the barometer was below normal over practically the entire North American continent and the adjacent waters of the North Pacific Ocean, and another cyclone was developing in the Gulf region. Within a few days the flow of cold air from the north was again in operation and temperatures east of the Rocky Mountains became once more far below the seasonal average, except in the South.

By the middle of the month the cyclone referred to above had developed and moved to the Atlantic coast, causing heavy snows from central Arkansas and northern Oklahoma northeastward over the middle Mississippi Valley, the northern watershed of the Ohio, and portions of the Lakes region. Unusually deep snow now covered practically the entire central and northern districts from the Plains region eastward. About the middle of the month pressure above the normal overspread Alaska and the adjacent districts, moving within the next few days to the southeastward and further reenforcing the cold already existing throughout the eastern United States.

WEATHER OF LATTER HALF OF JANUARY.

With little modification, the pressure continued slightly above normal from the middle to the end of the second decade over the central districts of the United States; and as far north as observations extended, the center of the greatest departure above the normal appeared along the south Alaska coast and over the nearby waters of the North Pacific. There was a diminution of pressure to the south and east and well-developed lows appeared in the west Gulf region and east of the Great Lakes about the 19th. (See CHART XV, Jan. 19.) Although pressure considerably above normal now existed in nearly all districts north of the United States, no unusual cold was being experienced in those regions; in fact, for a week or more preceding that time the temperatures at Eagle, Alaska, had been but slightly below zero (F.). Farther southeast in the Great Plains region of western Canada, Medicine Hat had temperature about normal, but in the United States temperatures in the upper Mississippi Valley were near 25 degrees (F.) to 30 degrees (F.) below normal.

About the 20th low pressure suddenly developed in central Alaska, and during the following few days extended southeastward over western Canada, and by the 23d the center had apparently entered the United States, at which time pressure was low over the entire central and northern districts west to the Rocky Mountains and north over nearly the whole of Canada and Alaska. Despite the low pressure in the eastern districts of the United States, unusually cold weather continued, but in the near Northwest warmer weather was experienced for a few days, the decreasing pressure along the northern boundary inducing southerly winds. During this period high pressure was again developing in the North Pacific, and by the middle of the last decade it had become established over Alaska and western Canada, where the severest cold since December was being experienced, the temperature about this time at Eagle and Dawson going to −50° F.

This cold wave was only of short duration in these far northern districts, but as it extended southward into the United States it brought, in some districts, the severest weather of the winter. The cold continued over much of the country east of the Rocky Mountains until the end of the month. CHART XVI, January 30, again illustrates the opportunity for easy movement of cold air from northern regions into the Central and Southern States. High pressure was now advancing from the interior of western Canada, where temperatures of from −30° to −50° F. were being experienced. At the same time, pressure was again low over the Gulf and southwestern districts, and cold, northerly winds, having initial temperatures far below zero, were advancing into the interior valleys. Here again, low pressure in the Gulf region favored the swift movement of cold air into the interior and Southern States, with little opportunity for heating, due to the expanse of the snow and ice covered areas over which it passed. Temperatures fell to −20° F. in Nebraska and to freezing in southern Texas. With pressure below normal in the Southwest, the way opened, likewise, for the movement of cold air into regions west of the Rocky Mountains; and the first severe cold of the winter prevailed in the far northwestern States at the close of the month.

Considering the period from about January 7 to 23, inclusive, 17 days, during which time temperatures in the east-central portions of the United States were almost continuously below normal, it is of interest to note that in the far north this period was very generally warmer than usual. At Eagle, Alaska, the average temperature from January 7 to 23 was above the normal continuously, except on two days, and the mean temperature for the period of 17 days, −6°F., averaged nearly 10 degrees (F.) above the normal. At Louis-

ville, Ky., a point nearly 2,000 miles farther south, the temperature was below the normal during the entire period, and on no day was it less than 10 degrees (F.) below; and the mean for the period, 15°F., averaged 20 degrees (F.) below normal. The only apparent explanation of this condition lies in the fact that the distribution of the pressure was such as to afford easy movement of cold air from northerly regions into the middle and southern portions of the United States without the usual gain of heat. This was made possible (1) partly because of the great blanket of snow over which these winds blew, thus maintaining to more than the usual extent, or even augmenting, the initial cold of their origin by affording opportunity for more intense cooling by radiation by night and for lack of heating due to the reflection of the sun's heat by day, and doubtless (2) partly due to the fact that the temperature of the upper layers of the atmosphere had become unusually low as a result of the long period of cold over the northern districts during the preceding month.

PRESSURE AND TEMPERATURE OF JANUARY AS A WHOLE.

In examining the daily charts showing the distribution of atmospheric pressure during January, 1918, over the United States and Canada so far as revealed by the observations at hand, two pronounced features are observed. First, the absence of areas of marked high pressure over northern districts, considering the unusual cold experienced in the central and eastern portions of the United States, and second, the far southerly courses pursued by both the HIGHS and LOWS in their movements across the country.

CHART XIX shows the departures of the surface air pressure for the entire month of January from the normal and the prevailing course of the winds. Examining this chart, it is seen that while pressure was only slightly above normal in the far northern districts, it was decidedly low to the southward and eastward, a condition already pointed out as favorable for the transfer of cold air into the United States from the great continental cold region of western British America and the adjacent portions of Alaska. The direction of the winds, as in December, was again largely from northerly quadrants east of the Rocky Mountains, while over the Plateau and Pacific Coast States they maintained the same general tendency from the west and southwest as in December.

CHART XVIII. Departure of the mean temperature, January, 1918, from the normal, forcibly illustrates the influence of the pressure distribution, of the air movement and of snow cover on the temperature over the United States. The region with the greatest departure of temperature below the normal is practically coincident with that in which the snow cover was the most above normal. (See CHART XVII, Average depth of snow on the ground during January.) Considering CHARTS XII and XVII, showing departures of pressure from the normal for December and January, respectively, it is seen that while there was a great reduction in the average air pressure from the first month to the second over all northern districts, the gradient in each case is similar, high pressure toward the northwest and lower pressure toward the southeast, with a corresponding air drift from the cold Northwest into the central and eastern portions of the United States.

CONTRAST BETWEEN DECEMBER AND JANUARY.

Contrasting the pressure characteristics of the two months it will be observed that during December strong nticyclones were projected into the central portions of the United States from the high-pressure belt lying near the Arctic Circle. These in their passage southward were materially warmed by constant contact with a warmer atmosphere and, during a portion of the month, by a warmer earth's surface with unfrozen rivers and lakes still giving off their stored heat. Thus, although still cold, when they reached the interior of the United States, they were, nevertheless, many degrees warmer than when they started on their long journey.

During January, however, a wholly different type of distribution prevailed. There was, in the main, no great high-pressure area in the far north from which strong anticyclones could move southward, nor was the temperature steadily lower than usual over that region; but pressure was far below the normal over the southern and eastern districts of the United States. This condition set up a gradient that virtually drew from the northern districts air not abnormally cold for the season, which on passing over the nearly universal cover of snow and ice that had now accumulated over the greater part of the United States retained its original temperature to a much greater degree than during December.

DECEMBER AND JANUARY TEMPERATURES.

It is of interest to note that in December the average temperature at Dawson, in the British Yukon, was —51° F., and at Louisville, Ky., it was 26° F., a difference of 77 degrees. In January the average temperature at Dawson was —13° F., and at Louisville 20° F., a difference of only 33 degrees. Assuming that the temperatures in the United States east of the Rocky Mountains during the two months were to some extent influenced by those prevailing to the northward, as shown by the atmospheric drift, it is clear that local air and surface temperatures must have exerted a considerable influence in modifying the degree of cold experienced during the two months. In other words, had the conditions that apparently retarded the warming processes in January over the eastern United States prevailed to a like extent during December, we should expect that at Louisville the December average temperature, instead of being 26° F. above zero, would have been nearly as many degrees below that point. Or, had the cold over northern districts been as severe in January as in December and the rate of warming continued unchanged the mean temperature at Louisville for January should have been approximately —15° to —20° F.

We may, then, logically assume that the cause of the continued low temperatures over the eastern half of the United States during January, 1918, was in large measure the lingering after-effect of the unusual cold of the preceding month (1), augmented by the pressure gradient, moderate as compared with December, but which still encouraged the prevalence of northerly winds over the interior of the country.

IS COLDER WEATHER POSSIBLE?

Entering the field of speculation as to the opportunities for periods of more severe cold than have heretofore been officially recorded in the United States, the facts presented by the actual degree of cold that persisted in December, 1917, over the far northern districts of the western continent, and the opportunities for the penetration of such cold to lower latitudes without material warming up, as experienced in January, 1918, discloses the easy possibilities of unusual winter temperatures in the United States. It is quite within bounds to assume that cold weather similar to that of December, 1917,

might continue an additional month or more over the far northern districts, and with a similar pressure distribution to the southward; in which case, without any change in the orderly procession of the forces dominating our weather, there could easily exist in the United States temperatures continuously so far below previous records, as to substantiate fully as the truth the traditions of severe cold experienced in the past at similar latitudes in Europe.

RESULTS ATTENDING THE SEVERE COLD OF JANUARY, 1918, OVER THE EASTERN TWO-THIRDS OF THE UNITED STATES.

At the beginning of the month the ground was snow covered north of a line extending from South Carolina to the northern Rocky Mountain region. Frequent extensive storms sweeping well to the southward in their movements across the country added to the depth and surface extent of the snow, and by the middle of the month the greater part of the country was covered. The depths had reached unusual proportions in the Ohio and middle Mississippi Valleys and thence northward over the Lakes region and northeastward to New England. At points in these regions some of the heaviest snowfalls and severest drifting ever known occurred; and the great transportation lines were often badly crippled and at times completely paralyzed. Wagon roads were blocked for long periods, the distribution of food and fuel was greatly delayed and much actual suffering was experienced, particularly on account of the intense cold and the general scarcity of fuel.

Severe cold, deep snow, and the attendant disorganization of nearly all industrial activities persisted with only slight variations until the end of the month, except that during the last week some melting of the snow cover occurred over the southern drainage area of the Ohio and thence to northern Texas.

Much additional ice formed on the rivers and lakes during the month, and in some of the important producing sections the gathering of the crop was delayed because the thickness was too great to permit the use of the special implements employed in the work. On the Ohio and middle Mississippi Rivers the amount of ice at points was the greatest ever known. Gorges that formed in the Ohio early in December, 1917, held in some places throughout the month, and when they finally broke up late in January, or early in February, caused much damage to river interests (3). It is estimated that one-half the tonnage on the lower Ohio and portions of the middle Mississippi was destroyed by the heavy ice. At Cairo, Ill., it is reported that pedestrians crossed the Ohio River on the ice, an occurrence not previously related either in the known history or traditions of that place. At the mouth of the Chespeake Bay, where ordinarily no interruptions occur to traffic, there were 15 days during the month on which it was impracticable on account of the ice barriers to operate car floats between Cape Charles and Norfolk. Late reports from far northern regions indicate that the ice conditions were the worst in many years. In Hudson and Davis Straits, ice was observed in unprecedented quantity nearly all the past summer, and vessels that usually visit points in Hudson Bay during each summer, were unable to reach the more northern points on account of the heavy ice.

Farm work of all kinds remained practically at a standstill, much corn still remained in the fields ungathered, and wheat not protected by a snow cover was badly damaged by the cold. In the Southern States, winter oats were killed or their growth greatly retarded, and in the great winter trucking districts only the hardier vegetables made appreciable growth, and some that survived the cold of December were further damaged during January.

As in December, the weather conditions west of the Rocky Mountains were almost the reverse of those to the east. In these western regions warm westerly or southwesterly winds, induced by low areas entering the United States east of the Rocky Mountains and moving well southward along their eastern slopes, prevailed throughout the month. In the absence of important cyclonic activity in that region little snow occurred at the lower elevations, and most of what occurred in the high mountains soon disappeared under the influence of the warm winds. At the close of the month practically no snow had accumulated in the mountain regions of the West, particularly in the Sierra Nevada, where the deficiency in the snow cover was the greatest ever know at that period of the winter, and a serious shortage in the water supply for irrigation and power purposes during the summer months was indicated.

THE WEATHER DURING FEBRUARY, 1918.

At the beginning of the month severe cold still persisted over the districts east of the Rocky Mountains, particularly from central Texas northeastward to the Great Lakes. At the same time an offshoot from an extensive depression that had rapidly developed over Alaska and the North Pacific overspread the northwestern districts of the United States, and within the following few days moved rapidly across the country, bringing temporary relief.

Anticyclonic conditions were quickly reestablished, however, by the rapid southward movement of a high-pressure area that developed, apparently, in the region just west of Hudson Bay. By the morning of the 4th the whole interior of the country was under its influence, and throughout the Middle West some of the lowest temperatures of the winter were experienced.

SUDDEN APPEARANCE OF WARM WEATHER.

As this cold area moved to the Atlantic Coast, another offshoot from a great area of low pressure over the North Pacific, Alaska, and western Canada entered the northern districts of the United States, and by the morning of the 5th covered the entire region from the middle Mississippi Valley, Great Lakes, and Hudson Bay, westward. Warm, southerly winds had now set in over the Missouri Valley districts, the temperature had risen 20 to 40 degrees (F.) or more (cf. Fig. 4), and the first permanent break in the cold that had persisted so constantly since early in December, was at hand. The low pressure advanced rapidly eastward, and by the morning of the 7th temperatures were above normal in practically all portions of the country for the first time in about two months.

Following closely the low-pressure area noted above, another advanced into the Middle West, and temperatures remained above the seasonal average for several days. About the 8th, high pressure moved into the Pacific coast States and gradually overspread all central and southern districts of the United States. With low pressure over Canada, however, the winds over the northern districts continued from their southerly course and temperatures were maintained above the normal very generally until near the middle of the month.

CHART XX, February 10, 1918, illustrates the general type of pressure that favored warm weather over the interior and northern districts of the United States from about the 5th to 15th. The high pressure overlying the central and southern districts apparently entered the United States from the middle Pacific by way of California, and hence lacked the great mass of cold air attending highs that move from more northern latitudes.

CHART XXI, February 15, shows a return of pressure distribution favorable for the reestablishment of cold weather over the United States. On this date, high pressure dominated the entire region north of the United States, while in the South and East the pressure was low. This type persisted in modified forms till after the close of the second decade, during which time severe cold was experienced more or less constantly in all northern districts east of the Rocky Mountains. The extreme cold of the earlier months of the winter was not reached, due probably to the absence of an extensive snow cover and the lessened opportunities for the cold winds from the north to maintain their initial temperatures.

CHART XXII, February 23, typifies the pressure conditions existing during the last week of the month. The atmospheric circulation had now returned to the type existing earlier in the month; low pressure over the whole of British America with the center west of Hudson Bay, and moderately high pressure in the Gulf region and west to the Pacific. Air movement over the greater part of the United States was again from the south and unusually warm weather prevailed over the greater part of the country till the close of the month.

FEBRUARY MEAN PRESSURES AND TEMPERATURES.

CHART XXIII shows the average pressure distribution during February, 1918, and the general course of the prevailing winds, while CHART XXIV indicates the departure of the temperature from the normal. The almost uniform prevalence of southerly winds east of the 100th meridian clearly illustrates the effect of the pressure distribution and explains at once the unusual warmth that persisted during so much of the month as compared with the cold of the two months preceding. For the month as a whole the temperature averaged well above the normal over the greater part of the country, particularly in the central valleys, where it was in marked contrast with that of the preceding two months. The heavy body of snow on the ground at the beginning of the month disappeared rapidly, and at the close only the northern districts were snowbound. The breaking up of the heavy ice in the rivers and the discharge of the excess of water resulting from the large accumulation of snow was accomplished with much less damage and loss by overflow than had been feared, although in the Ohio and some of its tributaries the formation of several extensive gorges caused considerable damage.

The milder weather of February brought much relief to the mining and transportation interests and greatly relieved the suffering from cold due to a general scarcity of coal and other fuels. Much progress was made in farming operations usual to the winter season, which had been practically at a standstill since early in December.

Winter grains, which had entered the season in poor condition generally, and in portions of the important producing sections had been subjected to severe cold from lack of snow cover, responded to the favorable weather of the month in general and at the close gave promise of a much greater yield than was considered possible at the beginning.

COMPARISONS WITH PREVIOUS RECORDS.

Meteorological records made upon a basis sufficiently uniform for comparison as to the larger fluctuations of the weather have been maintained at a few points in the United States for more than a century, the longest records naturally being found in the earlier settled districts near the Atlantic seaboard. With the advance of civilization westward, interest in weather conditions was still maintained by individuals, who started new records at widely scattered points, despite the stress of existence; so we find as far west as the Mississippi River records extending back into the early part of the last century. At St. Paul, there is an authentic record of the daily and monthly temperatures running back to 1820, and at St. Louis, Mo., the record began in 1833, while at several points farther east, notably in Ohio, observations of weather conditions were begun nearly 100 years ago.

Examination of the records for all these years fails, in many cases, to disclose a winter with two consecutive months having as long continuous cold and as low average temperature as was experienced during the past winter. Along the northern border of the United States, as at St. Paul, Minn., the period in some cases was not the coldest of record in nearly 100 years; the mean temperature for December and January of the past winter was slightly higher than the same months of some other years, notably for December, 1857, and January, 1858. But at St. Louis, Mo., the mean temperature for the two months in question is the lowest in more than 80 years, and this is true to a very general degree over all interior and southeastern districts of the United States east of the Plains region.

At Portsmouth, Ohio, with a record of nearly 95 years, we find December and January of the past winter the coldest of record for the entire period. At Baltimore, Md., the record extends back more than 100 years, 1817 to 1918, during which time no two months combined had as low mean temperature as was recorded during December and January of last winter; although individual months had mean temperatures as low as, or lower than, either December or January, notably December, 1831, 1.4 degrees (F.) lower, and 1870, the same as December, 1917; while January, 1857, and 1893, were only slightly warmer than January, 1918. In more than a hundred years record at Philadelphia no combination of December and January temperatures gives a mean so low as that of December and January of the past winter, but the mean for January, 1857, 22.4° (F.), was 1.8 degrees (F.) lower than the past January, and that of January, 1856, 24.1° (F.), was 0.1 degree (F.) lower. The winter approaching nearest that just past in degree of cold on the average, particularly over the eastern districts, was that of 1856–57, December, 1856, being, as a rule, warmer than the same month in 1917, with January, 1857, somewhat colder than the same month of 1918. In portions of Northwestern Canada and over interior Alaska, December, 1917, was by far the coldest month of which there is official or other record.

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EFFECTS OF COLD WEATHER, WINTER OF 1917-18, ON VEGETATION.

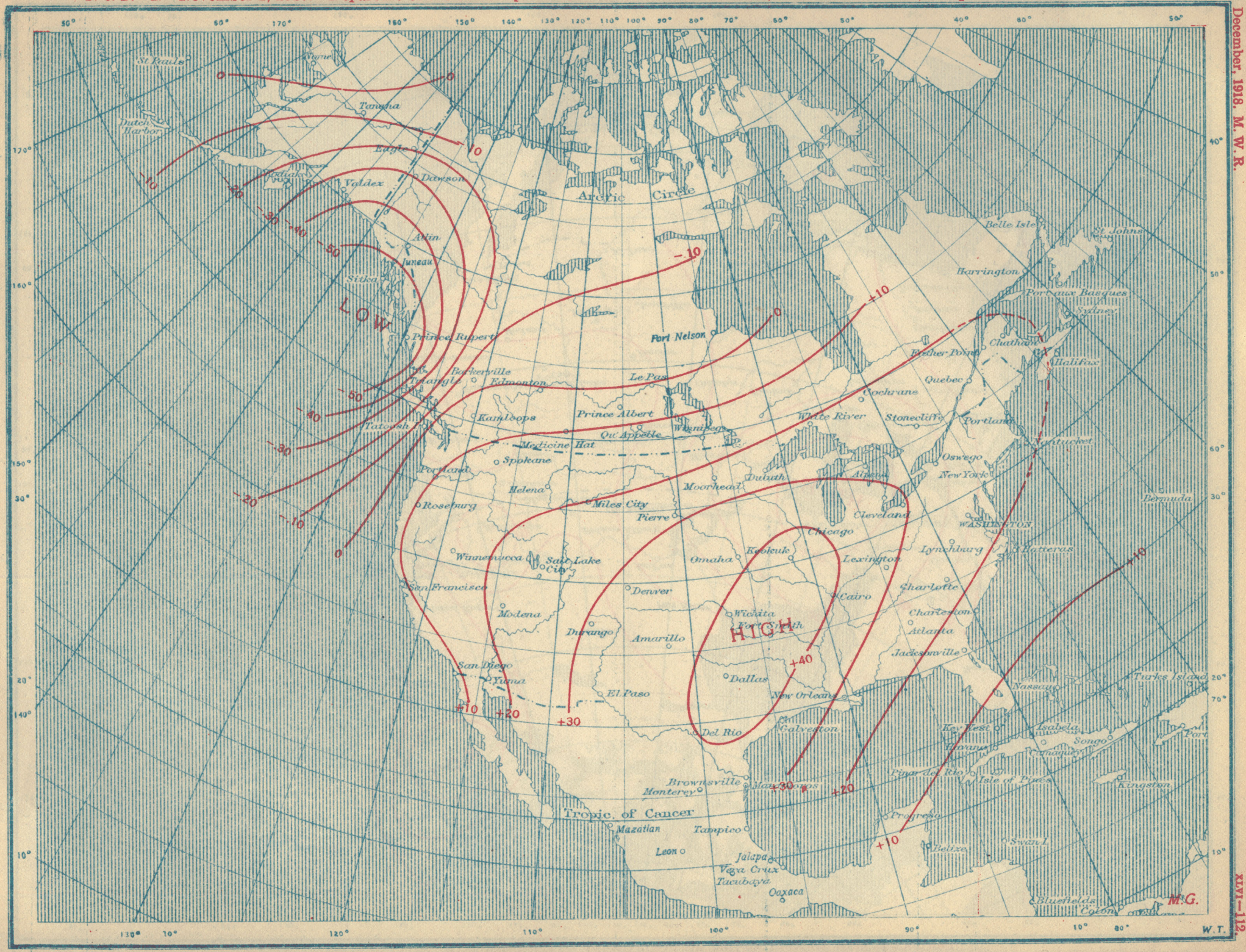
By J. WARREN SMITH, Meteorologist.

The unusually persistent cold weather during the months of December, 1917, and January, 1918, did not result in serious damage to the winter grains, fruit, and truck crops. In much of the Great Plains, the upper Mississippi Valley and the Lake region, there was some deterioration in the condition of winter wheat at the beginning of April, 1918, as compared with its condition on entering the winter, but in the first-named district much of the harm resulted, indirectly at least, from the poor condition of the plants due to the dry fall. In the middle Mississippi and Ohio Valleys and in most central and northern districts farther east, wheat was unusually well protected by a heavy snow cover during the prevalence of the cold weather, and by the first of April substantial improvement was reported in the condition of the crop over that at the beginning of the winter. On the whole, the unusually favorable spring in the principal wheat belt more than offset any damage that wheat may have sustained from winter killing.

Winter oats and truck crops in the southern States were much damaged, however, by the unusually severe winter weather, and considerable loss in stored vegetables was sustained where proper precautions had not been taken. There was also quite serious loss of unprotected cattle in some sections, particularly in Texas, where stock was in a weakened condition from lack of sufficient feed due to the protracted drought.

Except for winter killing of peach buds and some young peach trees from Arkansas and Missouri northeastward to New England and considerable damage to other fruit about the Lakes, fruit suffered little damage from the cold. Apples, citrus fruit, and cranberries were not unfavorably affected generally, except for some winter killing of cranberries in dry bogs of the Cape Cod district.

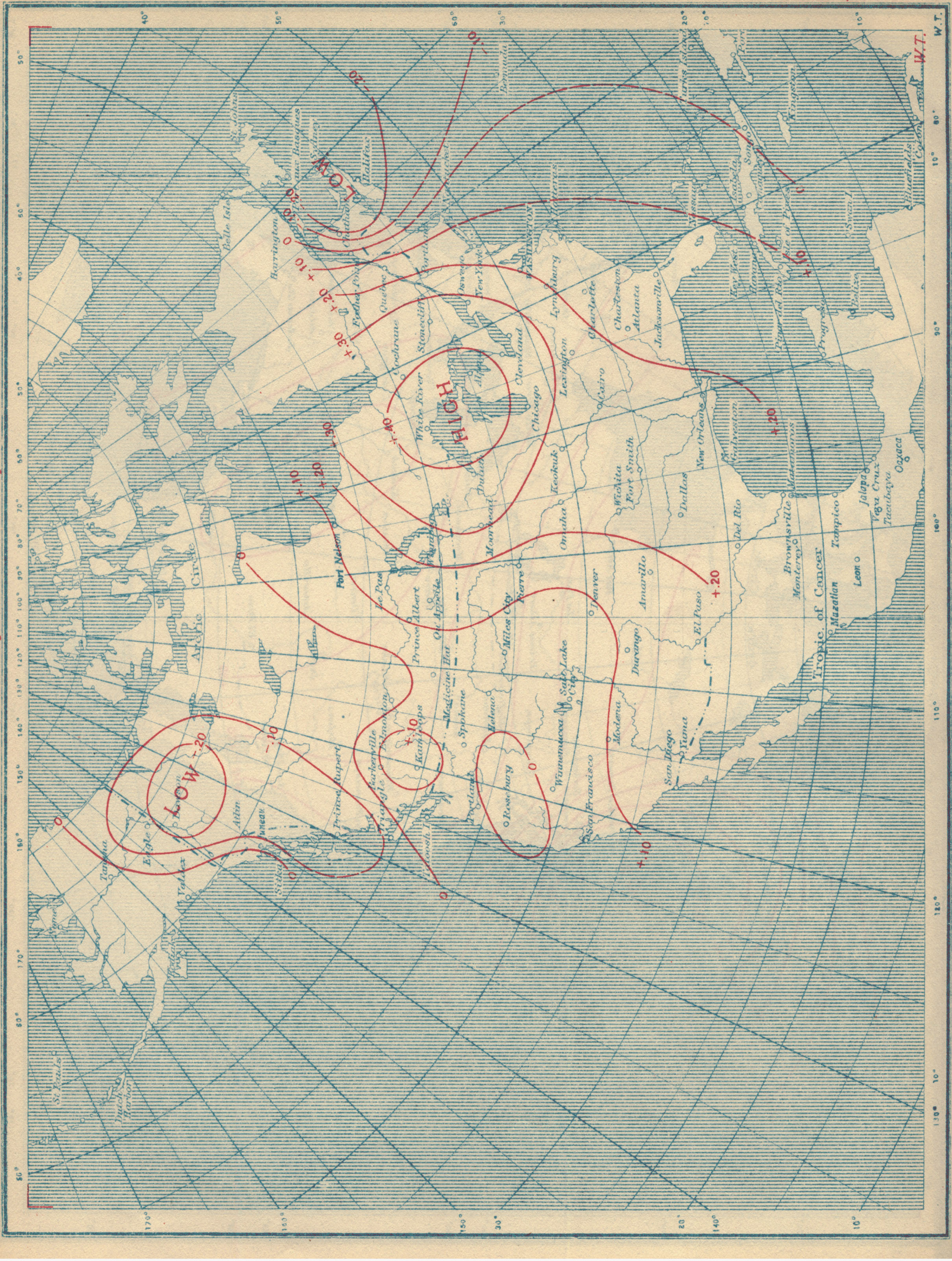
P. C. D. I.—November 2, 1917. Departure of the surface pressure from the normal. 8 a. m., 75th meridian time, except as indicated in the text.



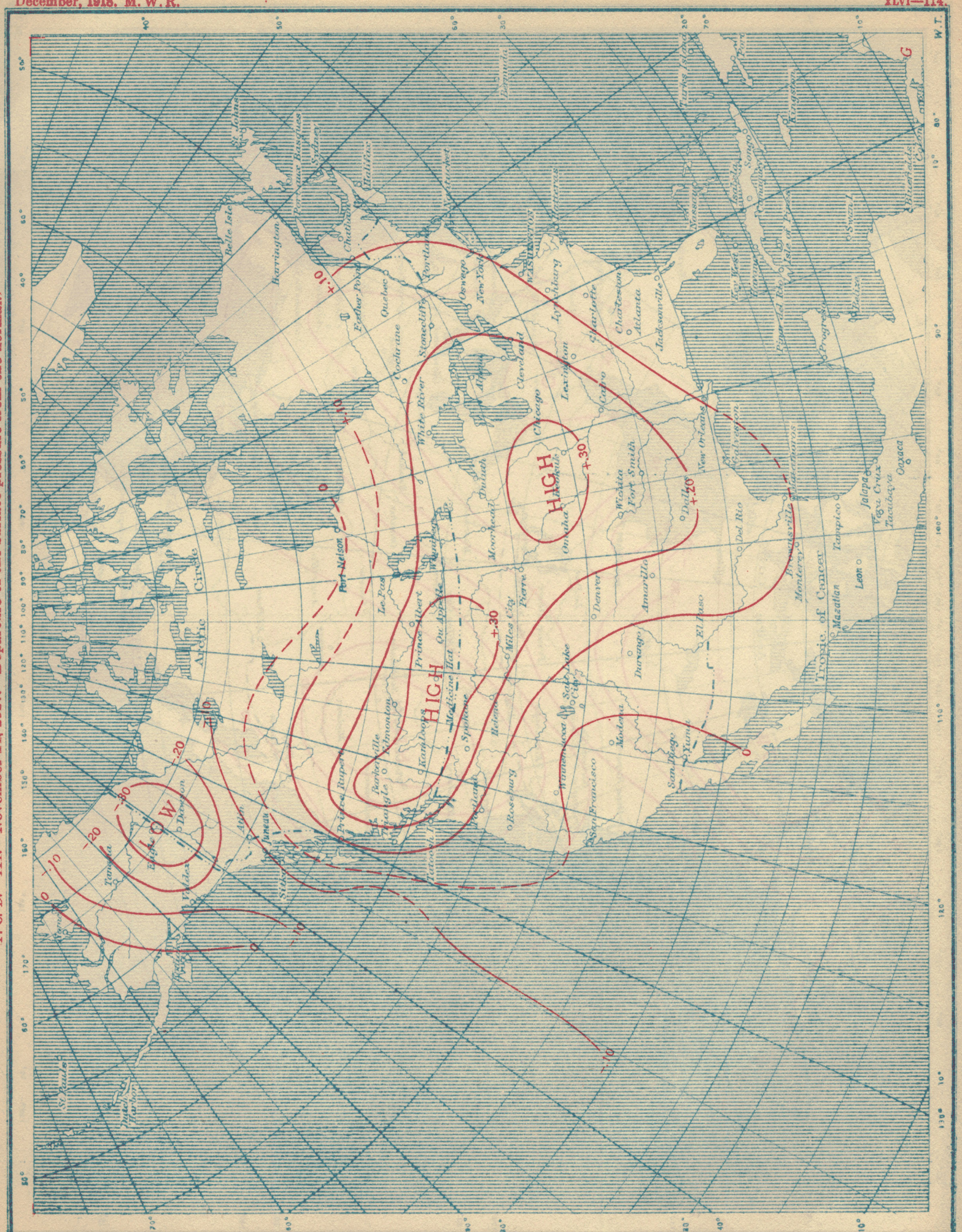
December, 1918. M. W. R.

XLVI—112.

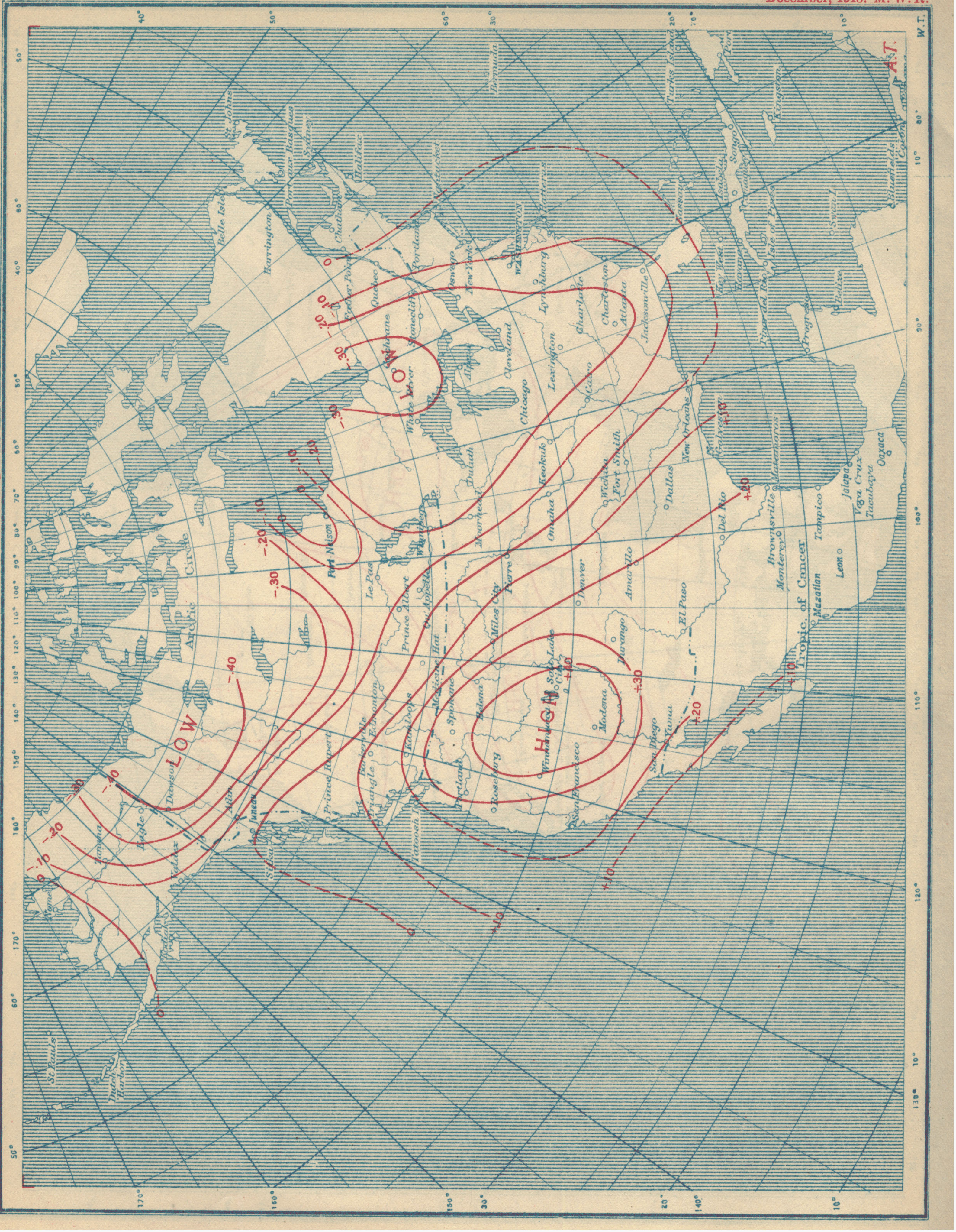
M.G.



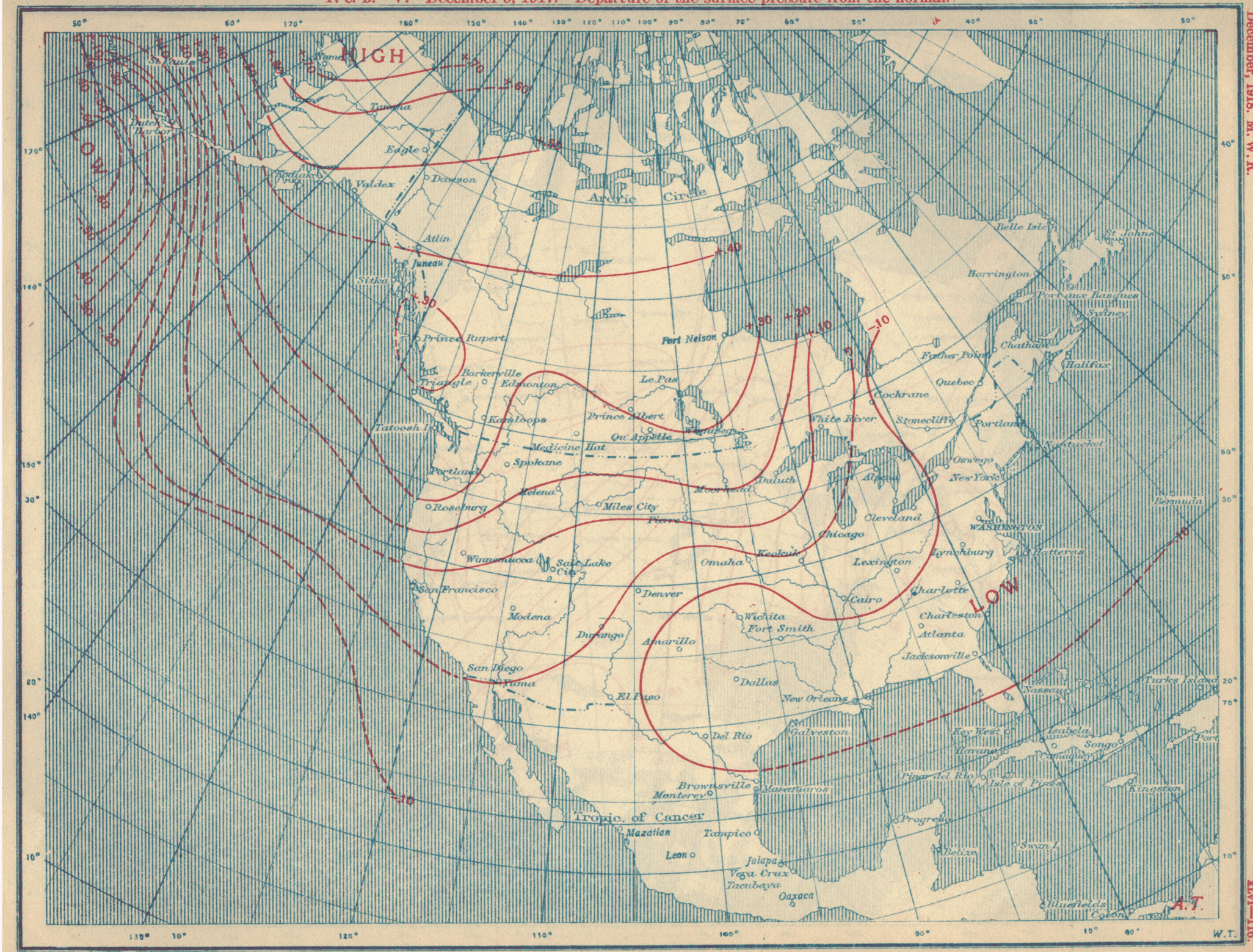
P. C. D. II.—November 8, 1917. Departure of the surface pressure from the normal.



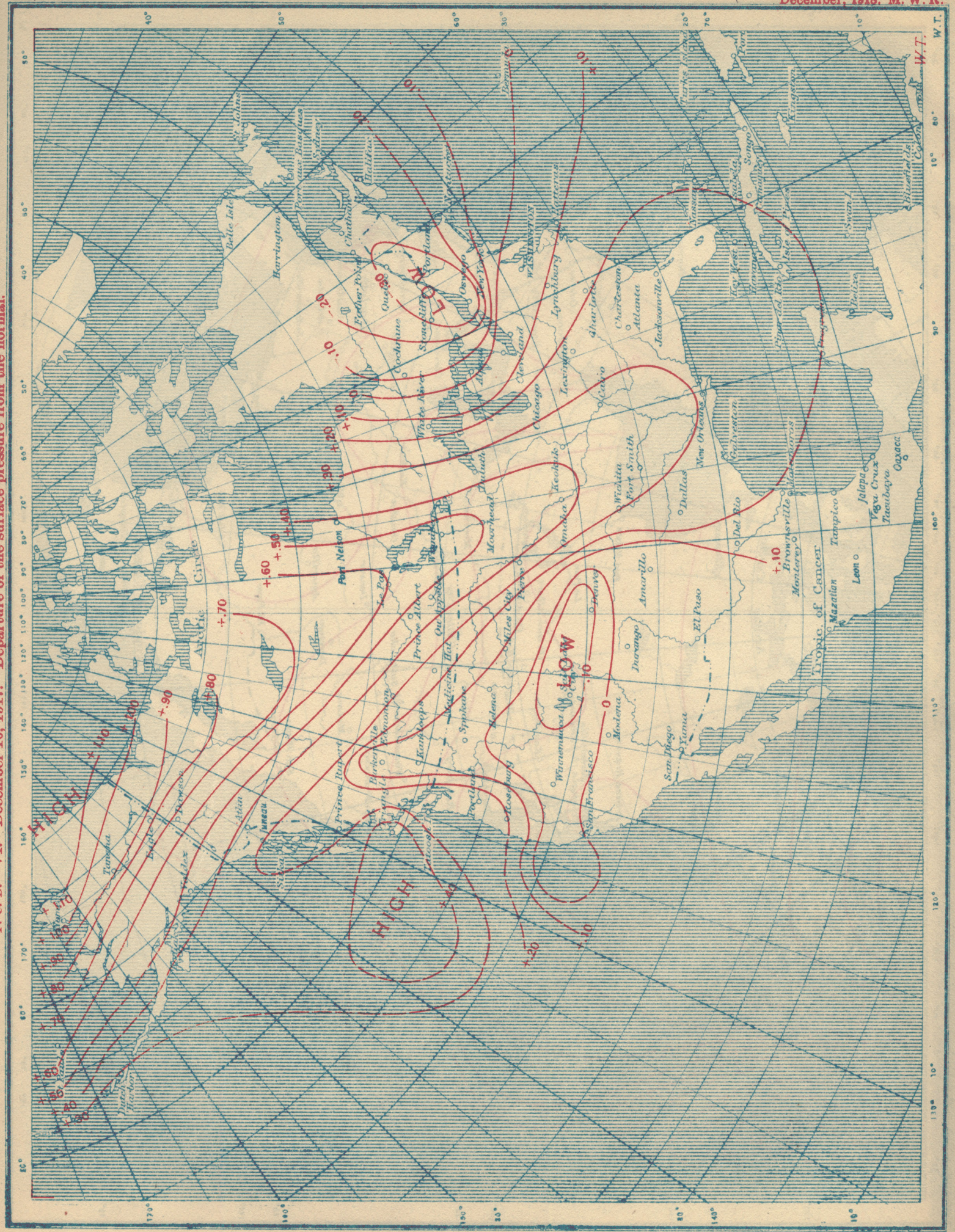
P. C. D. III.—November 14, 1917. Departure of the surface pressure from the normal.

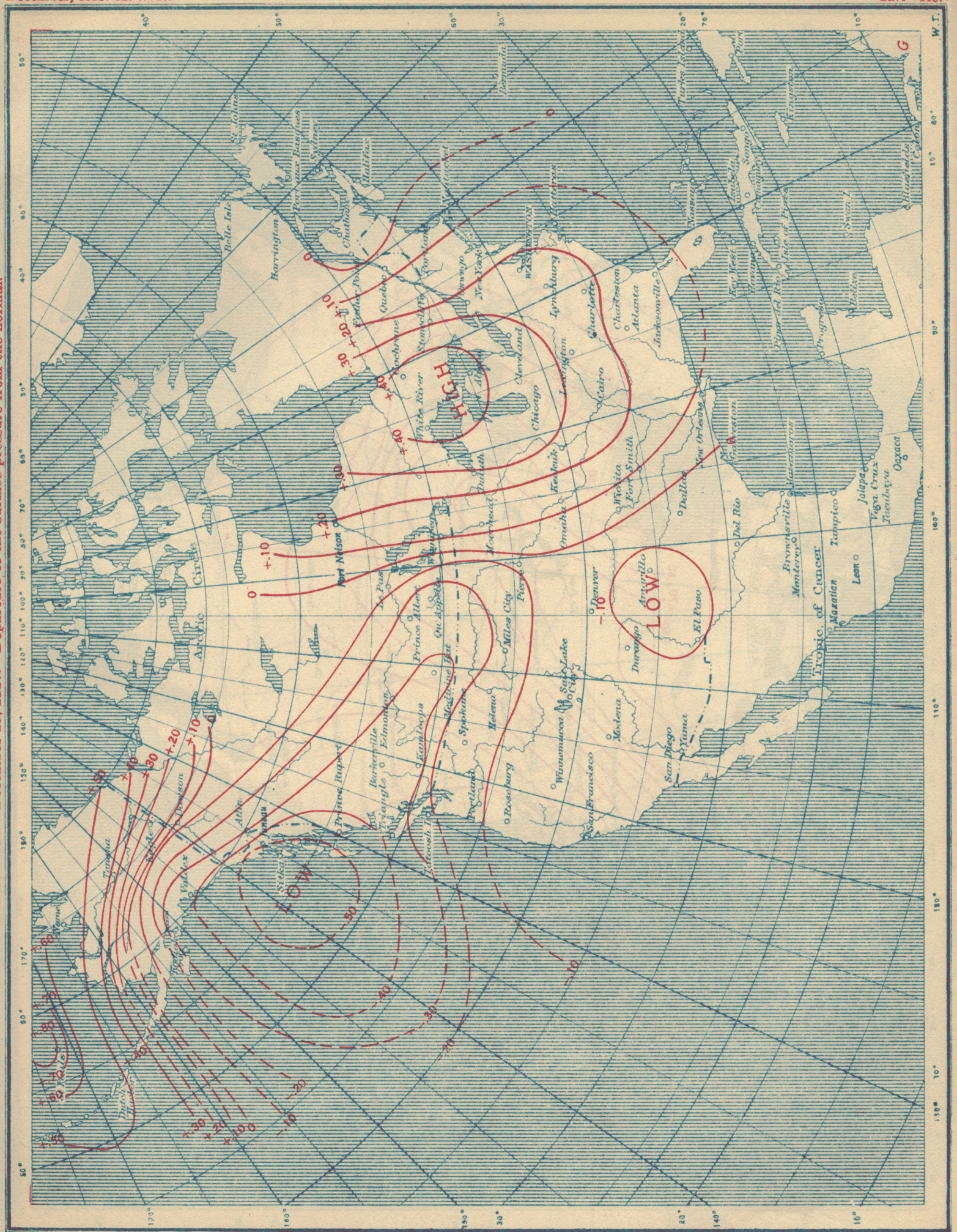


P. C. D. IV.—November 20, 1917. Departure of the surface pressure from the normal.


HIGH
LOW
LOW
+60
+50
+40
+30
+20
+10
0
-10
-20
-30
Arctic Circle
Tropic of Cancer
St. Paul
Dutch Harbor
Tanana
Eagle
Kodiak
Valdez
Dawson
Atlin
Juneau
Sitka
Prince Rupert
Barkerville
Triangle
Edmonton
Tatoosh I.
Kamloops
Medicine Hat
Spokane
Portland
Helena
Roseburg
Winnemucca
Salt Lake City
San Francisco
Modena
San Diego
Yuma
El Paso
Durango
Denver
Amarillo
Wichita
Fort Smith
Dallas
Del Rio
Brownsville
Monterey
Matamoros
Mazatlan
Tampico
Leon
Jalapa
Vera Cruz
Tacubaya
Oaxaca
Progreso
Belize
Swan I.
Bluefields
Colon
Port Nelson
Le Pas
Prince Albert
Qu'Appelle
Moosejaw
Moorhead
Duluth
Pierre
Miles City
Omaha
Keokuk
Chicago
Cleveland
Alpena
Oswego
New York
Bermuda
WASHINGTON
Lynchburg
Hatteras
Lexington
Cairo
Charlotte
Charleston
Atlanta
Jacksonville
Nassau
Turks Island
Key West
Havana
Isabela
Songo
Pinar del Rio
Isle of Pines
Kingston
Galveston
New Orleans
Cochrane
White River
Stonecliffe
Portland
Father Point
Quebec
Chatham
Halifax
Nantucket
Harrington
Port aux Basques
Sydney
Belle Isle
St. Johns
A.T.
W.T.

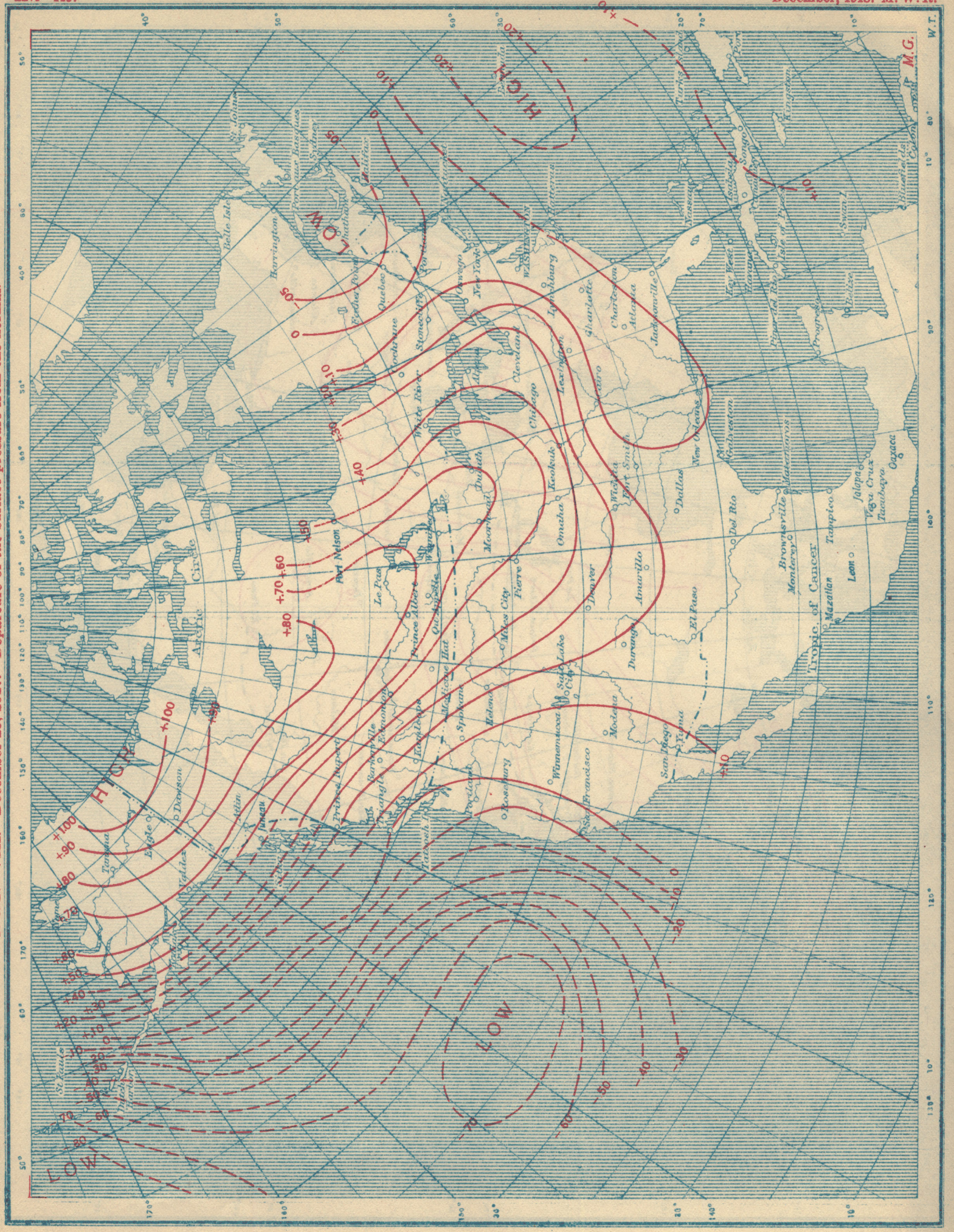
P. C. D. VI.—December 10, 1917. Departure of the surface pressure from the normal.



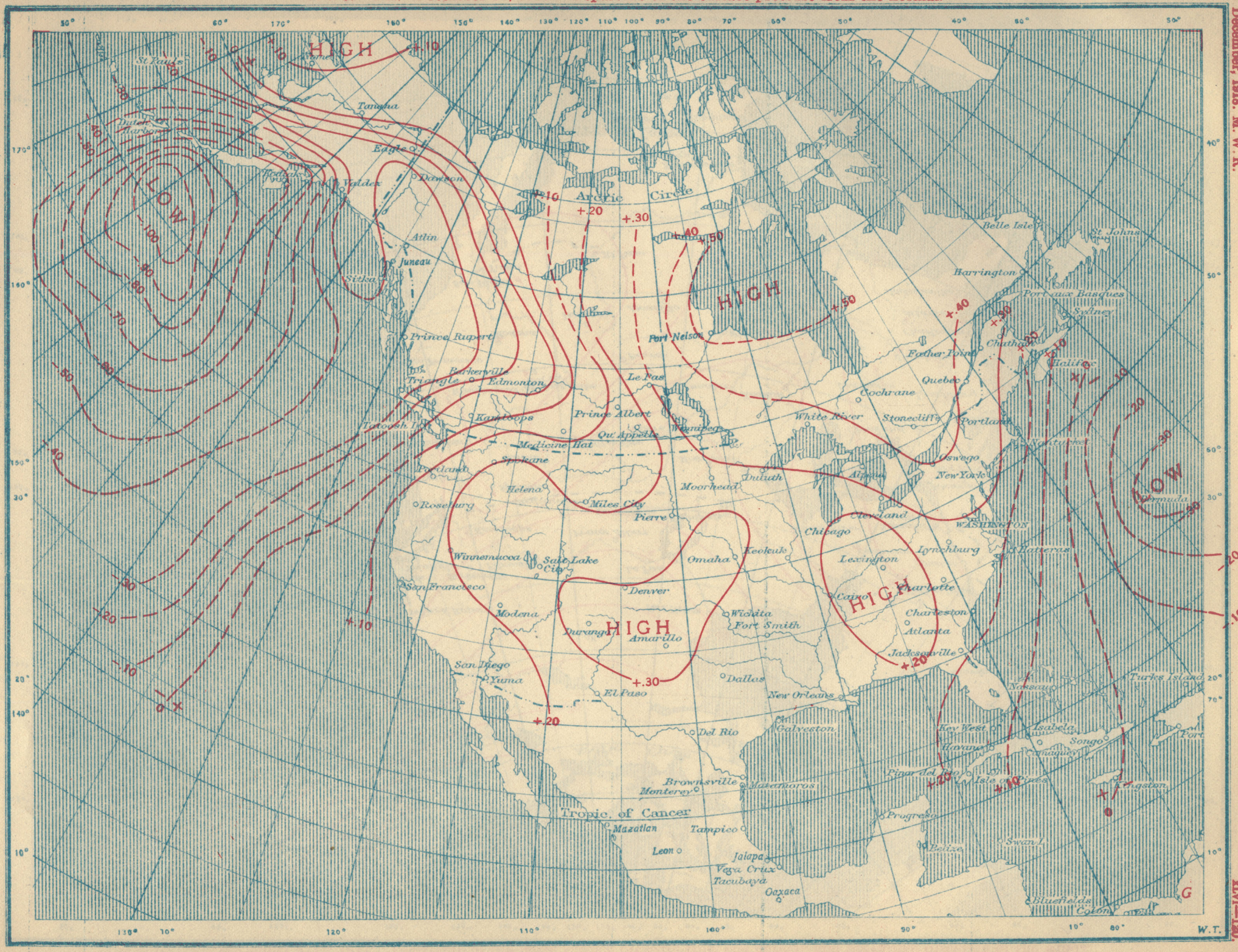


P. C. D. VII.—December 15, 1917. Departure of the surface pressure from the normal.

P. C. D. VIII.—December 25, 1917. Departure of the surface pressure from the normal.



P. C. D. IX.—December 31, 1917. Departure of the surface pressure from the normal.



December, 1918. M. W. R.

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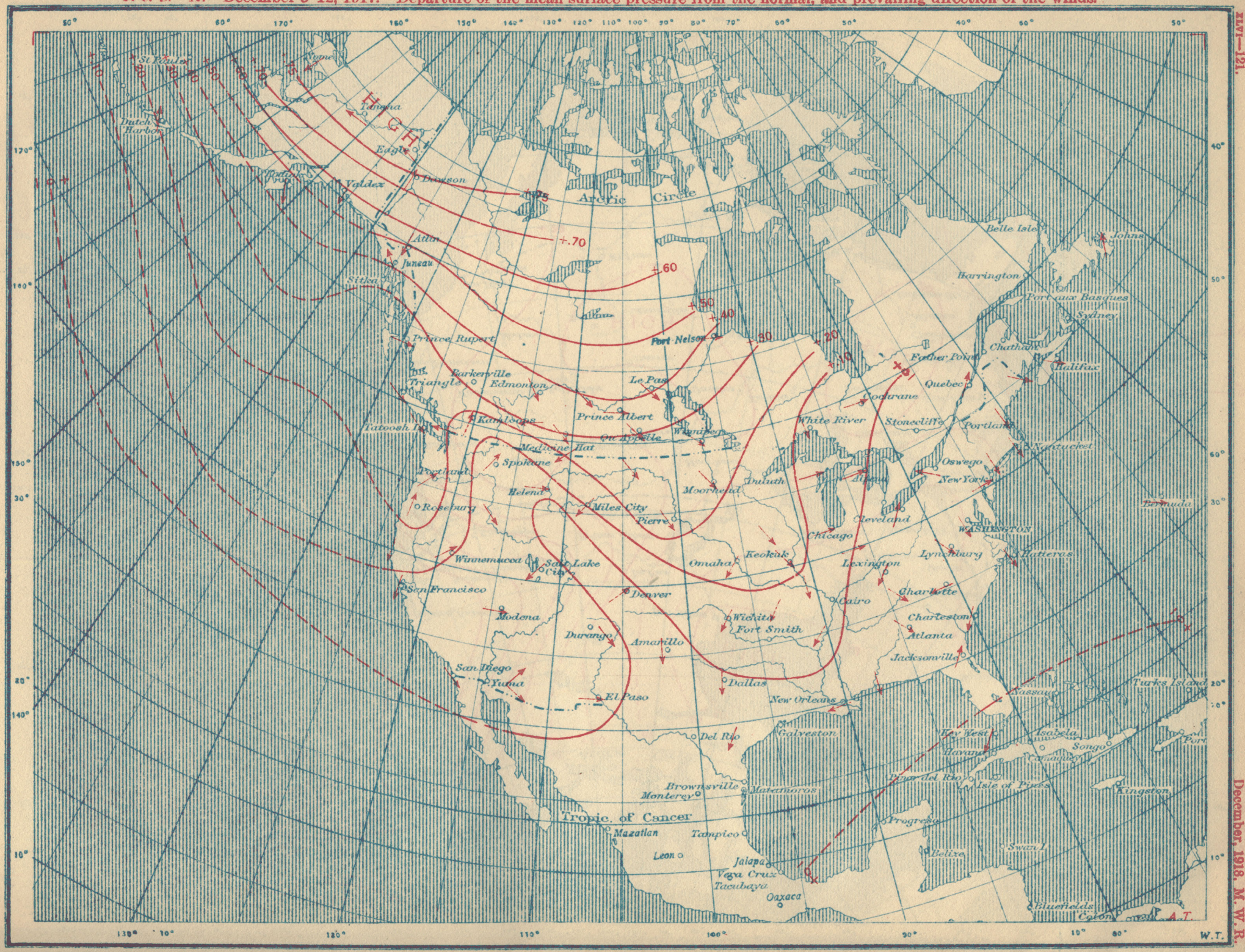
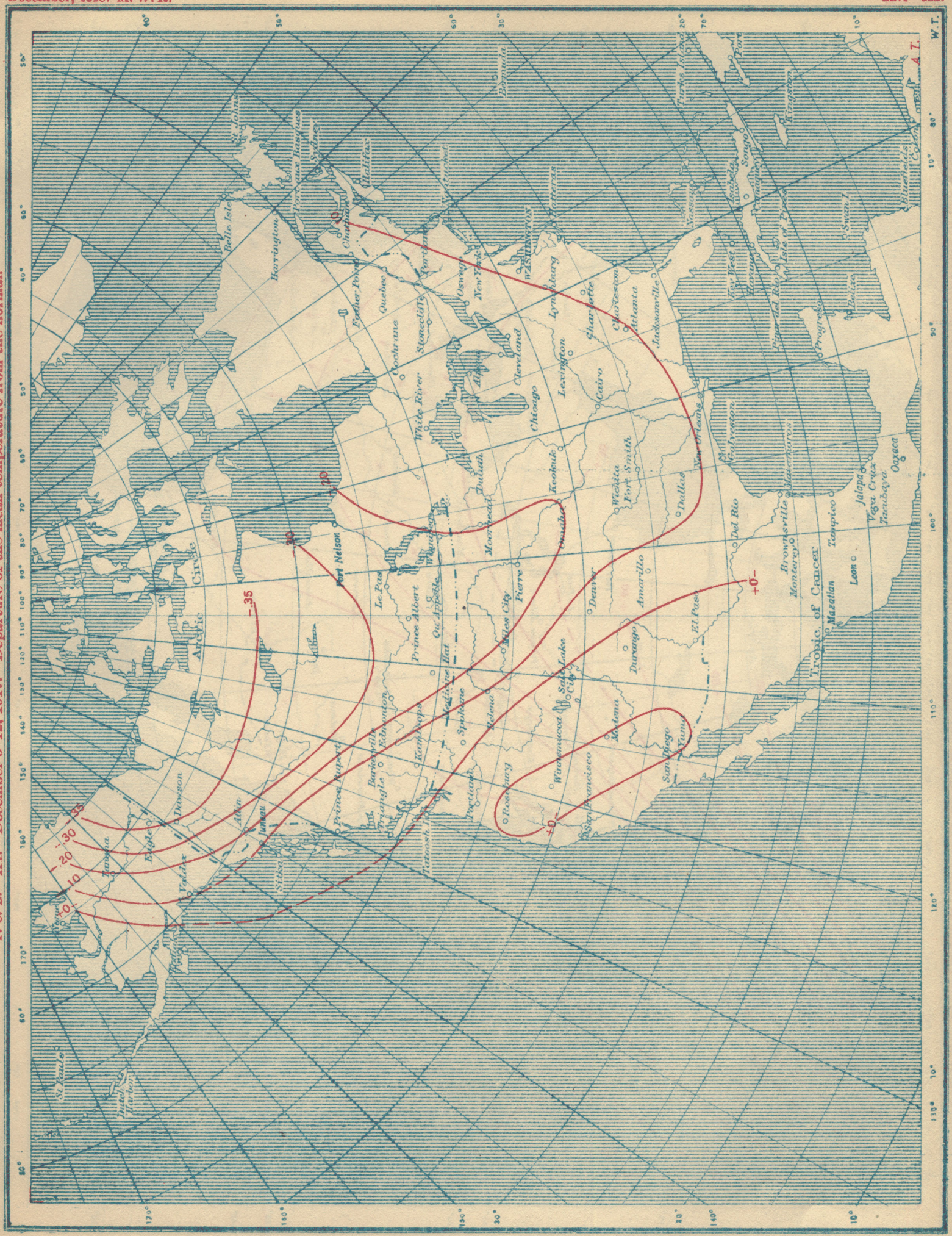
P. C. D. X.—December 3–12, 1917. Departure of the mean surface pressure from the normal, and prevailing direction of the winds.

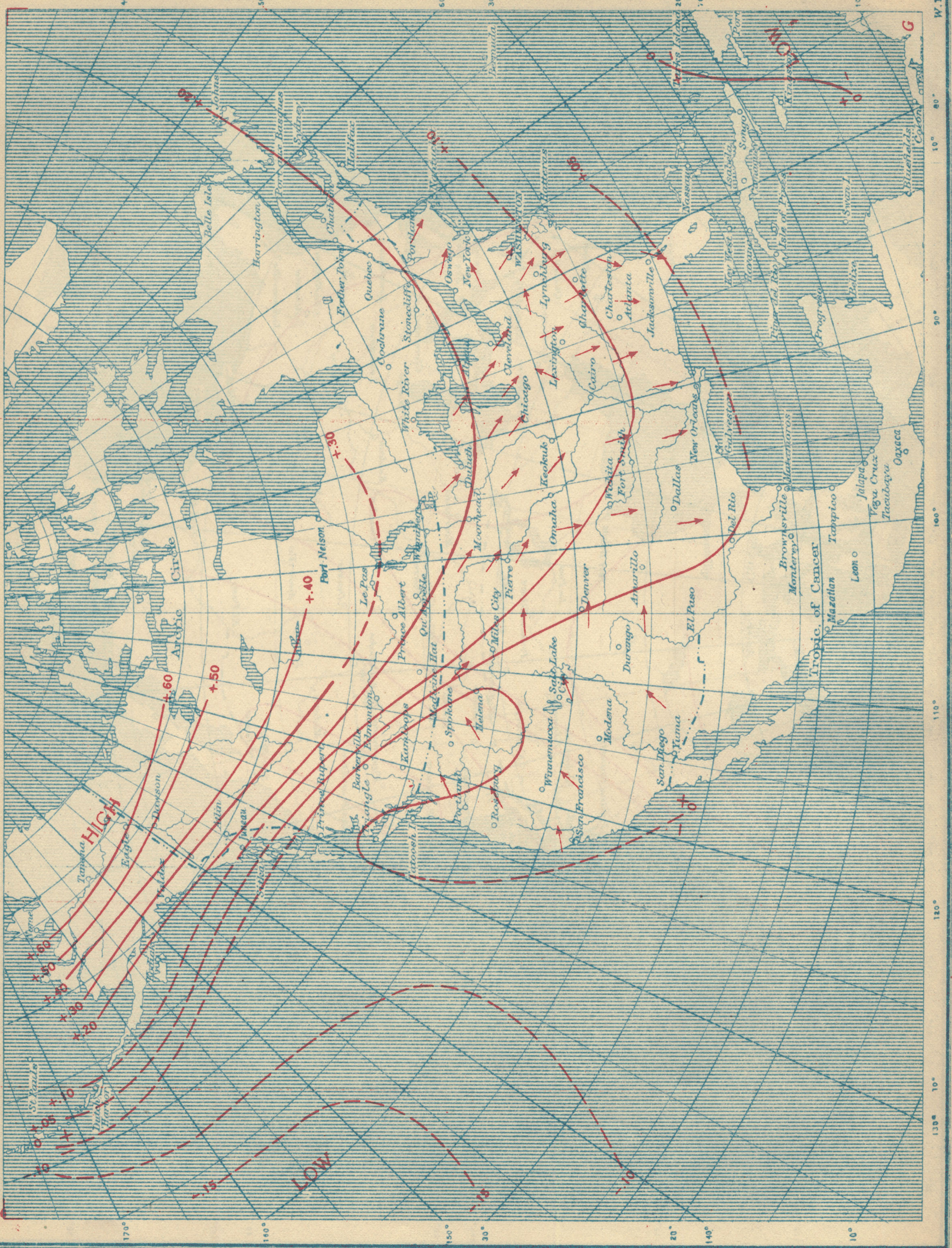


XLVI—121.

December, 1918. M. W. R.

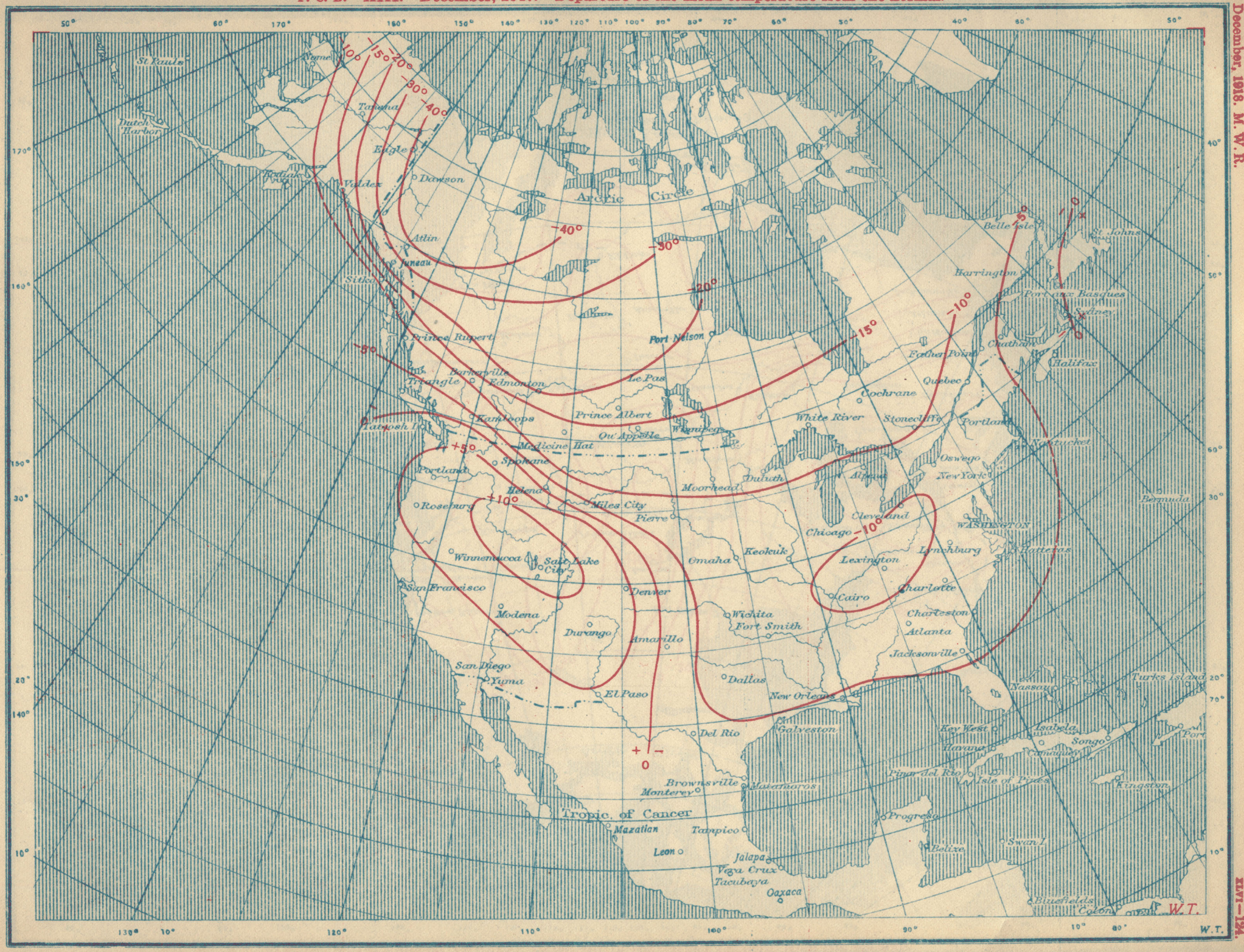
P. C. D. XI.—December 3–12, 1917. Departure of the mean temperature from the normal.

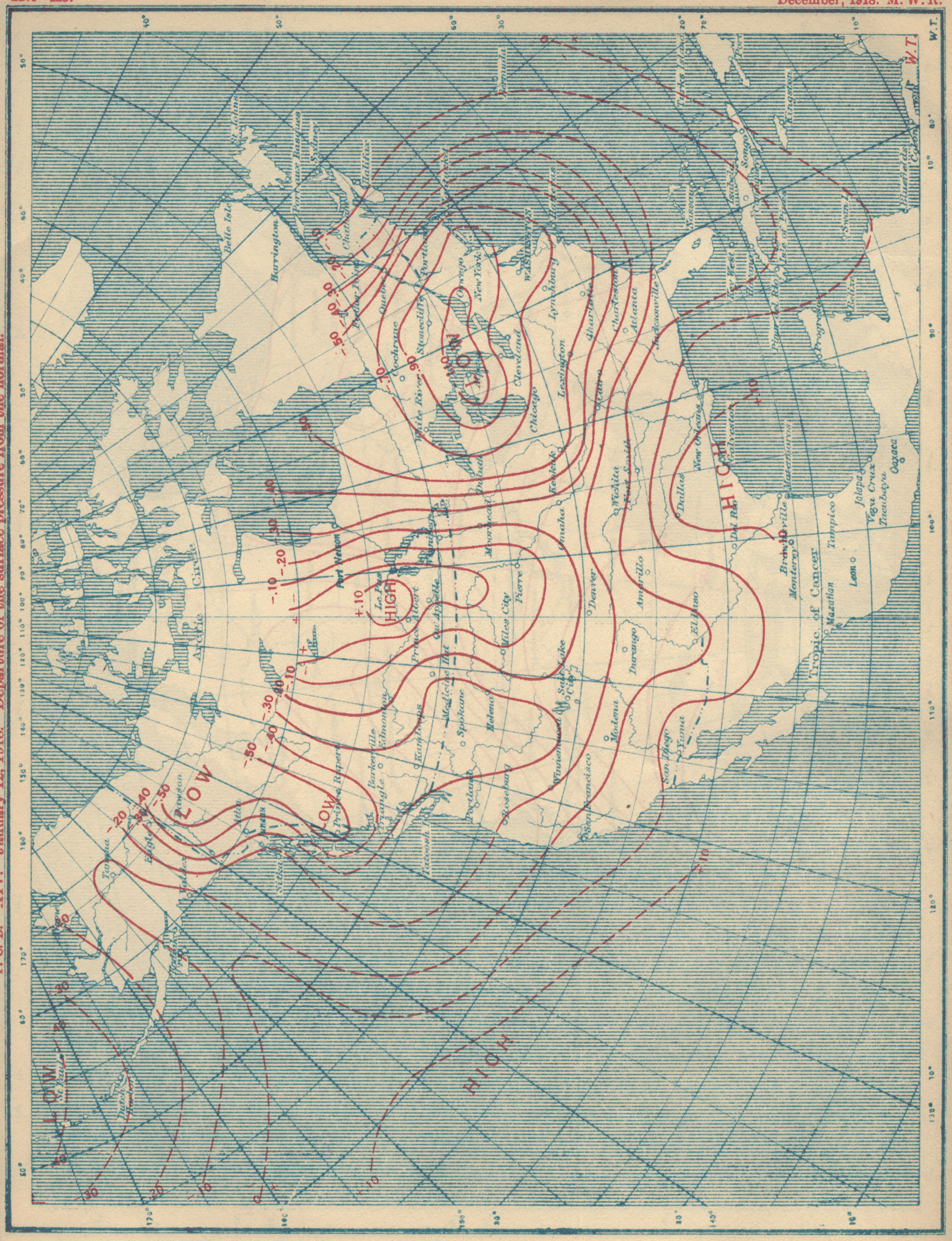




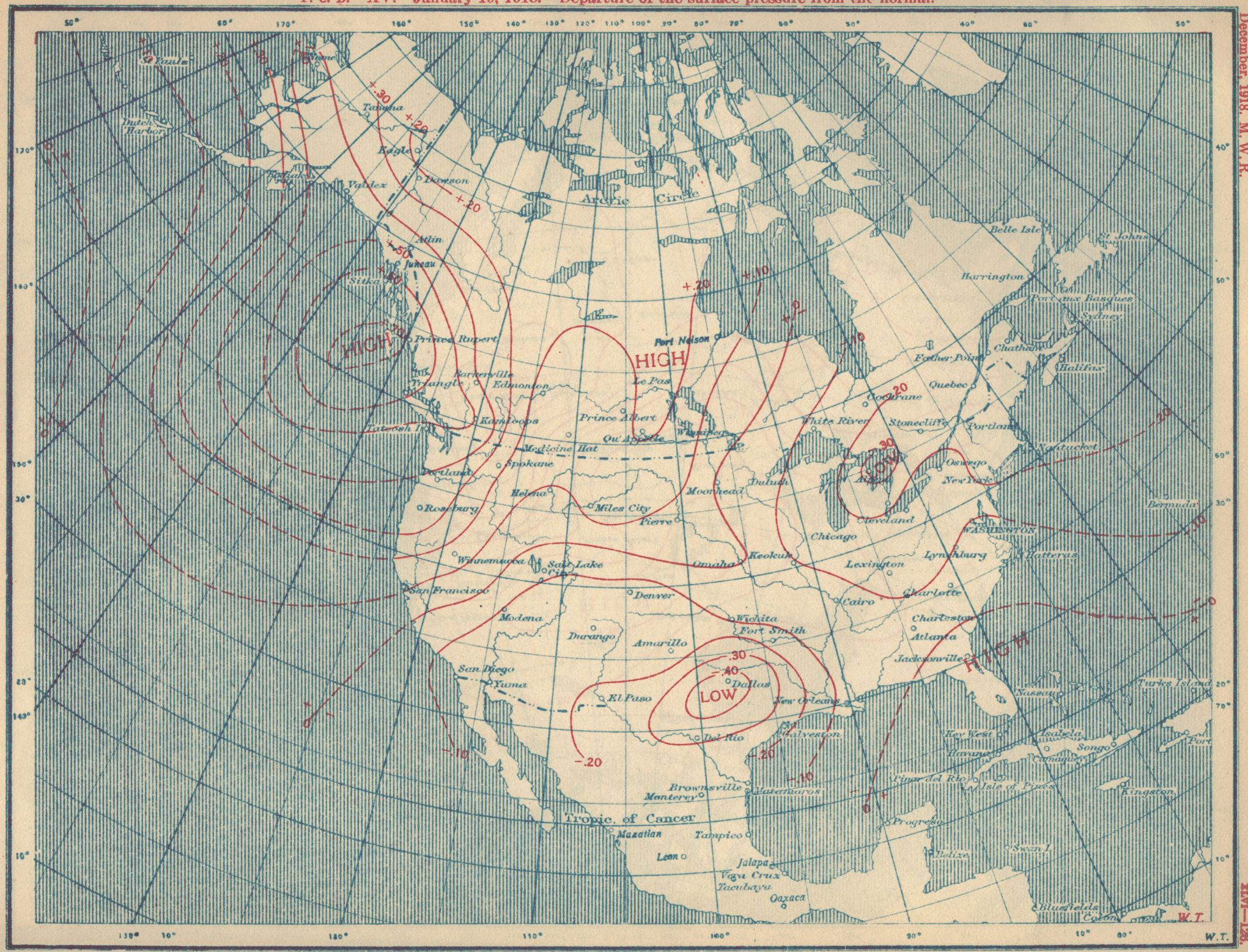
P. C. D. XII.—December, 1917. Departure of the mean surface pressure from the normal, and prevailing direction of the winds.

P. C. D. XIII.—December, 1917. Departure of the mean temperature from the normal.



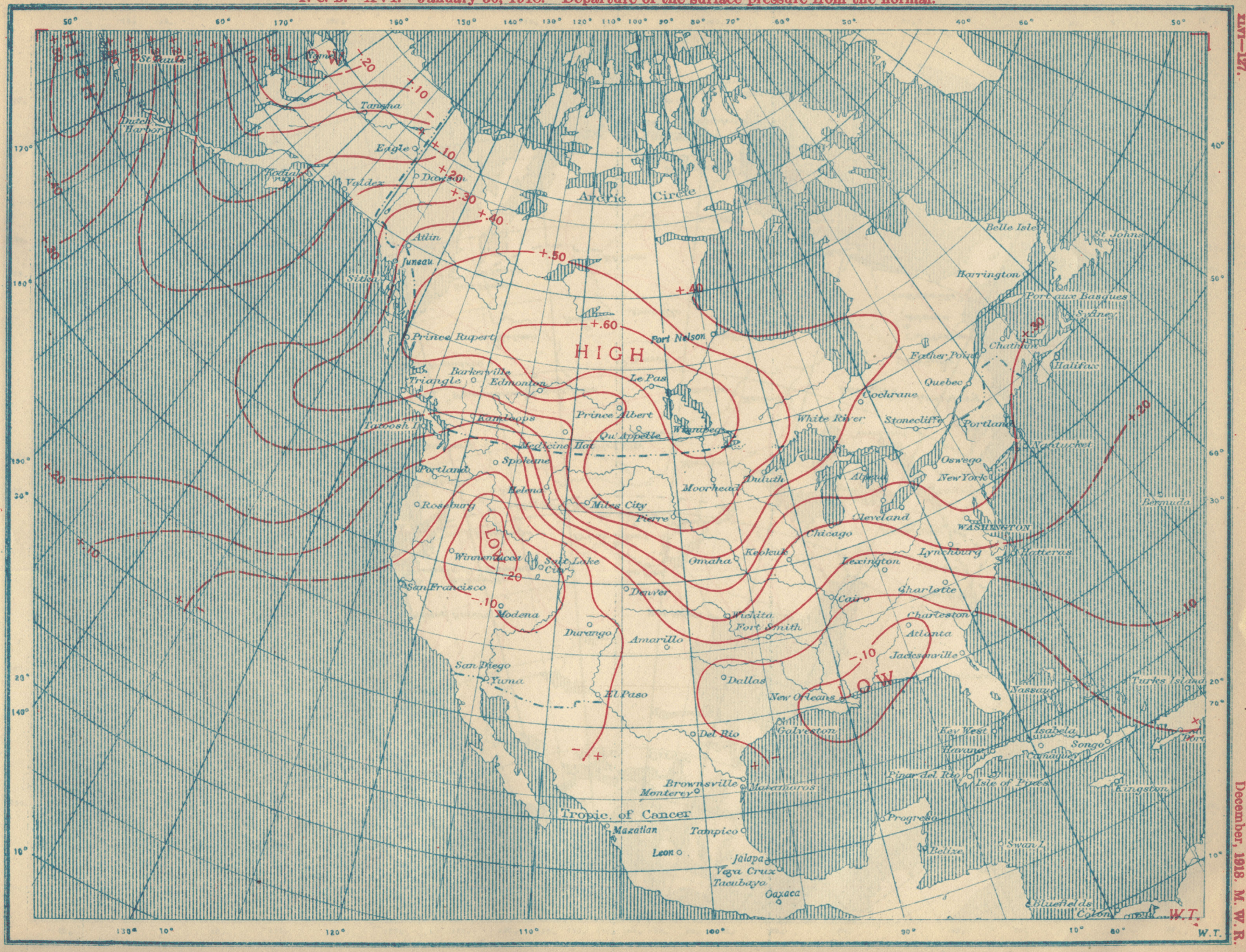


P. C. D. XIV.—January 12, 1918. Departure of the surface pressure from the normal.



December, 1918. M. W. R.

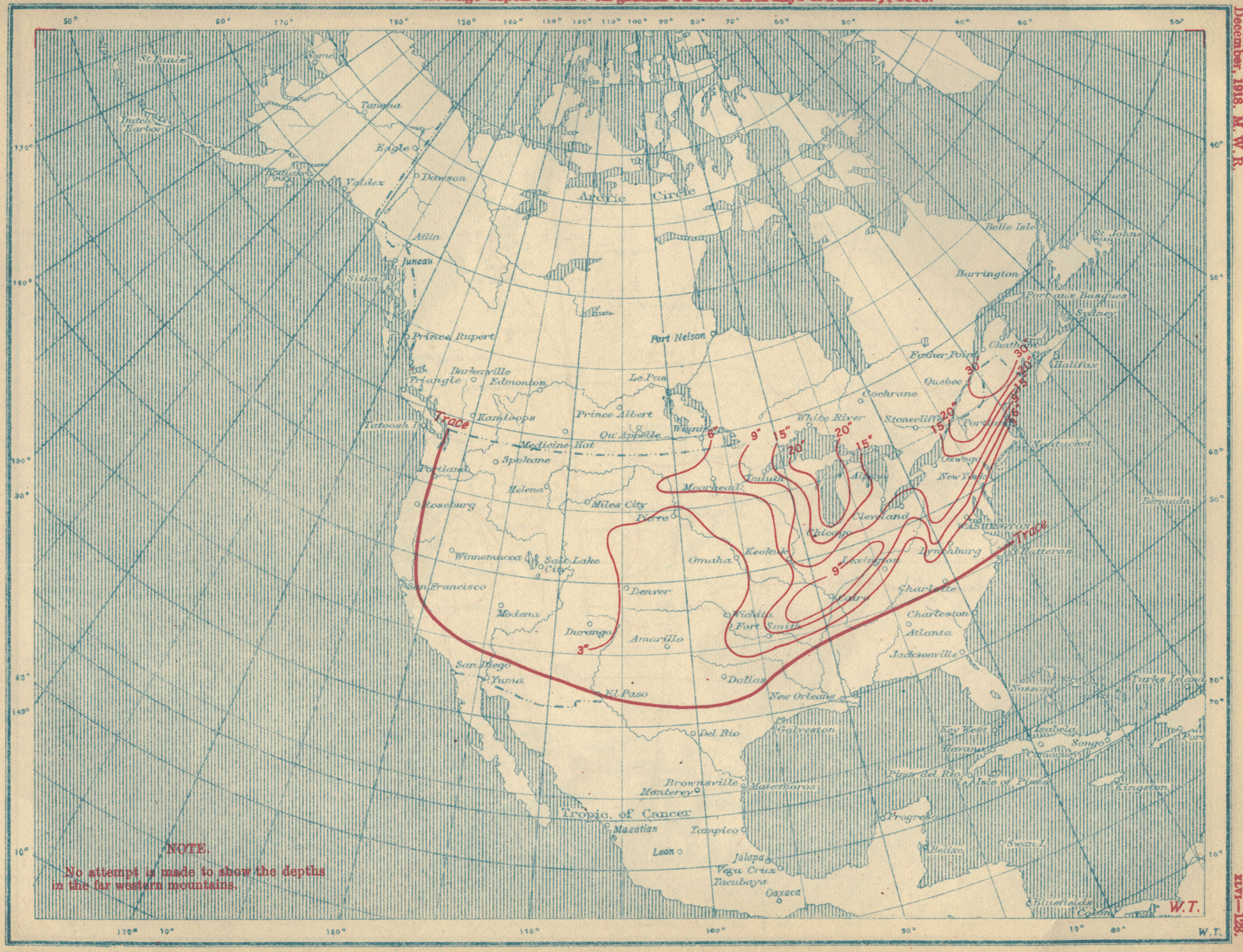
P. C. D. XVI.—January 30, 1918. Departure of the surface pressure from the normal.

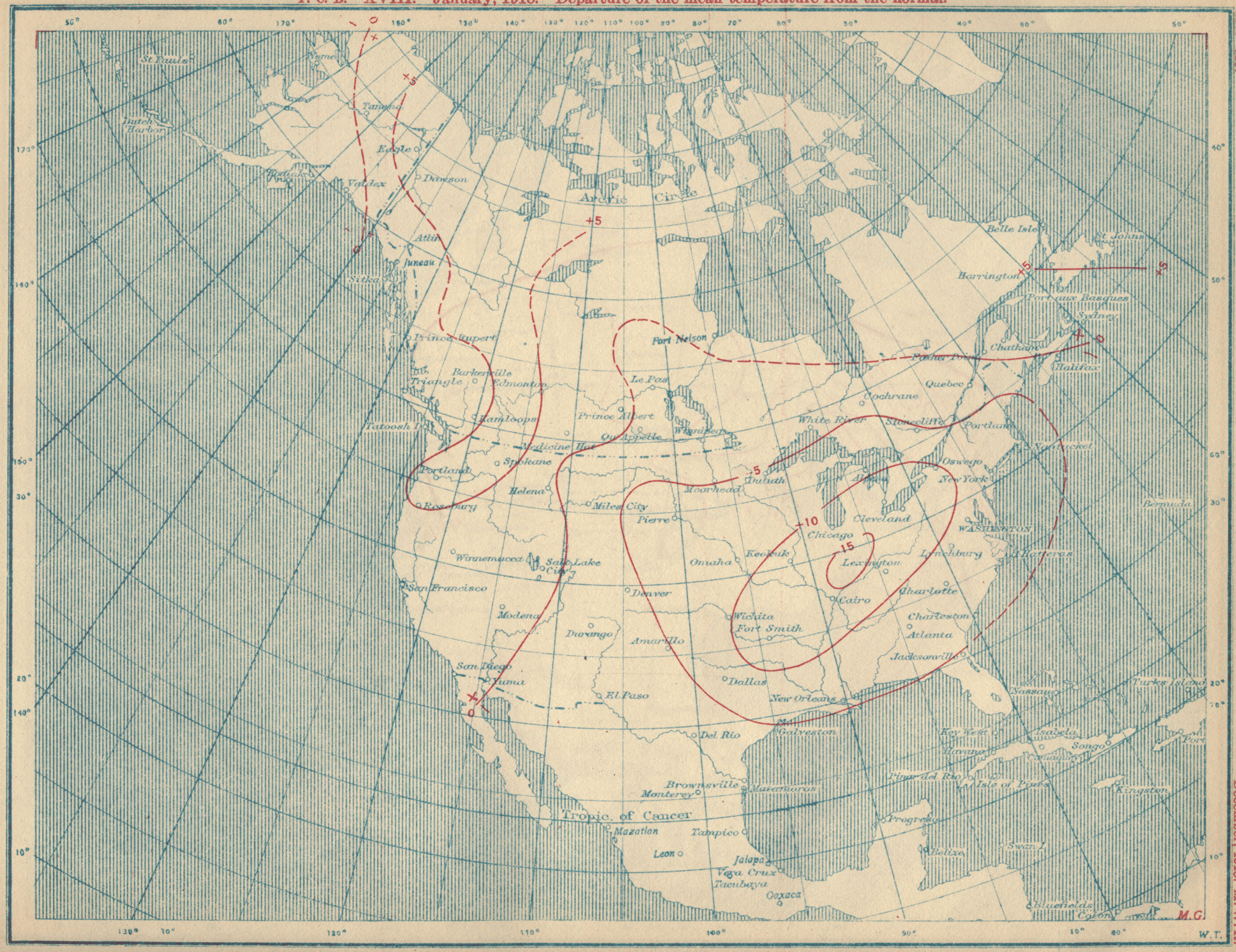


XLVI—127.

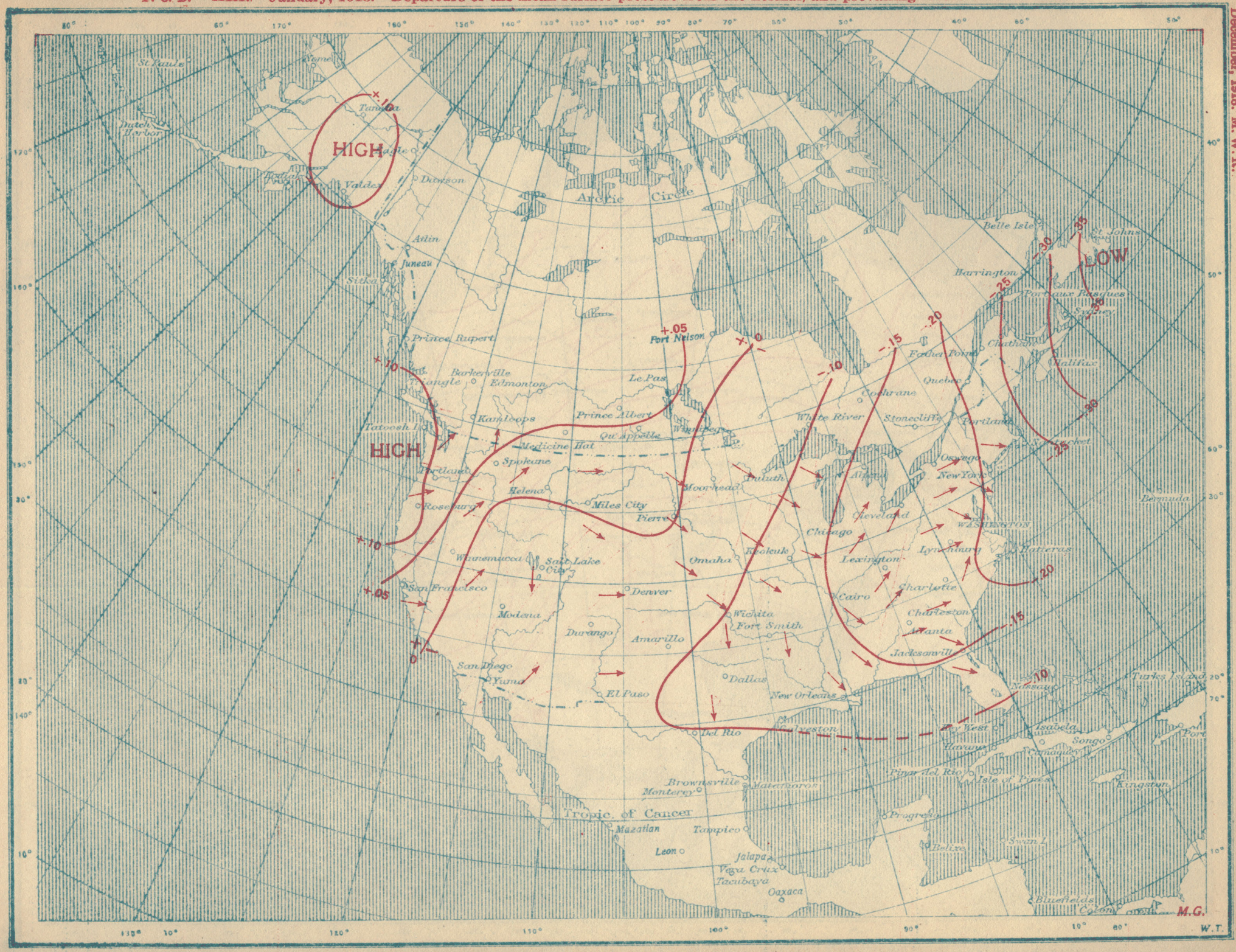
December, 1918. M. W. R.

P. C. D. XVII.—Average depth of snow on ground on the 4 Mondays of January, 1918.

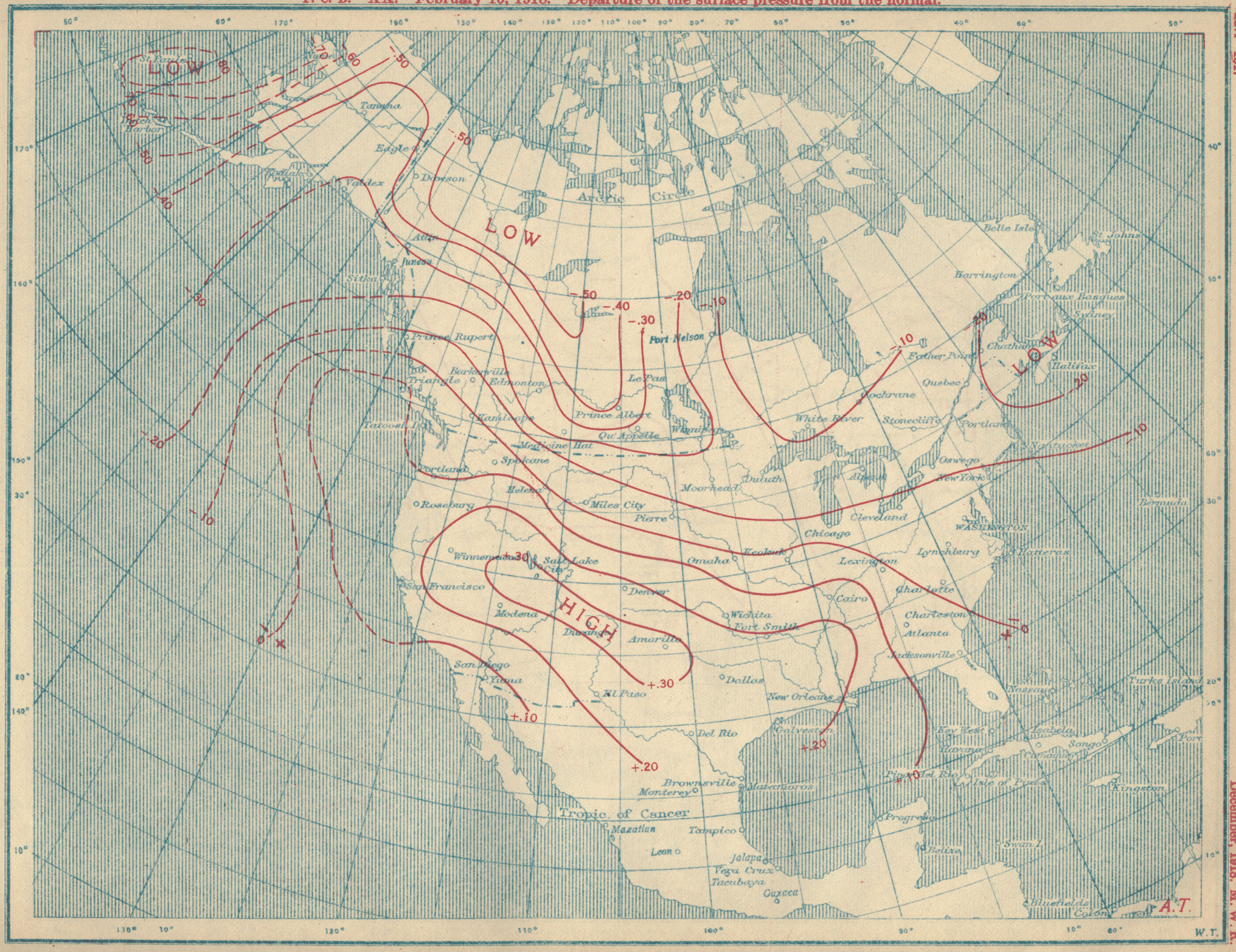


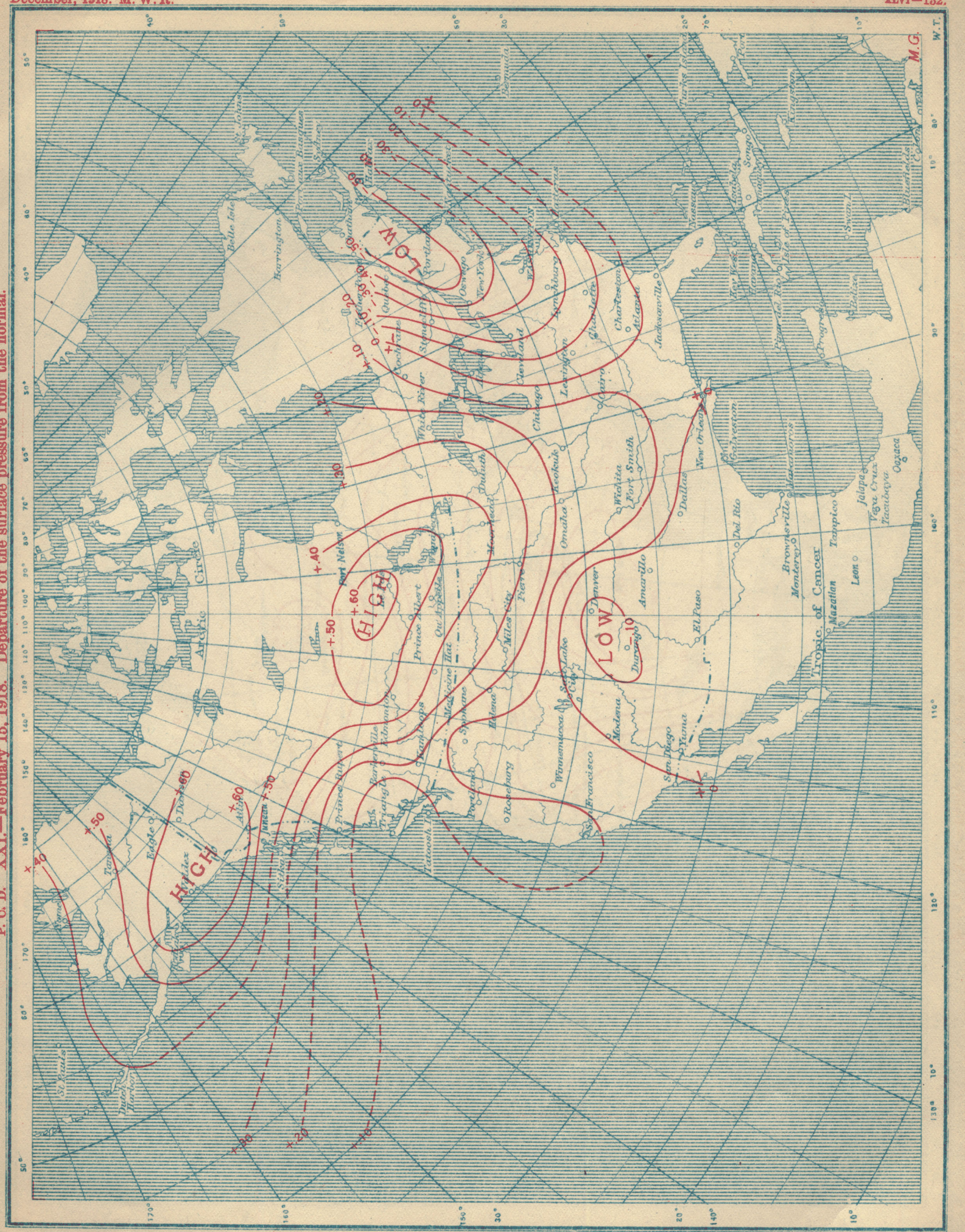

Arctic Circle
Tropic of Cancer
+5
0
-5
+10
15
St Paul
Dutch Harbor
Eagle
Dawson
Valdez
Atlin
Juneau
Sitka
Prince Rupert
Fort Nelson
Barkerville
Triangle
Edmonton
Le Pas
Kamloops
Prince Albert
Tatoosh I.
Medicine Hat
Qu'Appelle
Winnipeg
Spokane
Portland
Roseburg
Helena
Miles City
Moorhead
Duluth
Pierre
Winnemucca
Salt Lake City
Omaha
Keokuk
San Francisco
Denver
Modena
Durango
Amarillo
Wichita
Fort Smith
San Diego
Yuma
El Paso
Dallas
Del Rio
Galveston
New Orleans
Brownsville
Matamoros
Monterey
Mazatlan
Tampico
Leon
Jalapa
Vera Cruz
Tacubaya
Oaxaca
Progreso
Belize
Swan I.
Bluefields
Colon
Harrington
Belle Isle
St. Johns
Port aux Basques
Sydney
Chatham
Fisher Point
Halifax
Quebec
Cochrane
White River
Stonecliffe
Portland
Oswego
New York
Albany
Bermuda
Cleveland
Chicago
WASHINGTON
Lynchburg
Hatteras
Lexington
Cairo
Charlotte
Charleston
Atlanta
Jacksonville
Nassau
Turks Island
Key West
Havana
Isabela
Songo
Pinar del Rio
Isle of Pines
Kingston
Port
M.G.
W.T.

P. C. D. XIX.—January, 1918. Departure of the mean surface pressure from the normal, and prevailing direction of the winds.

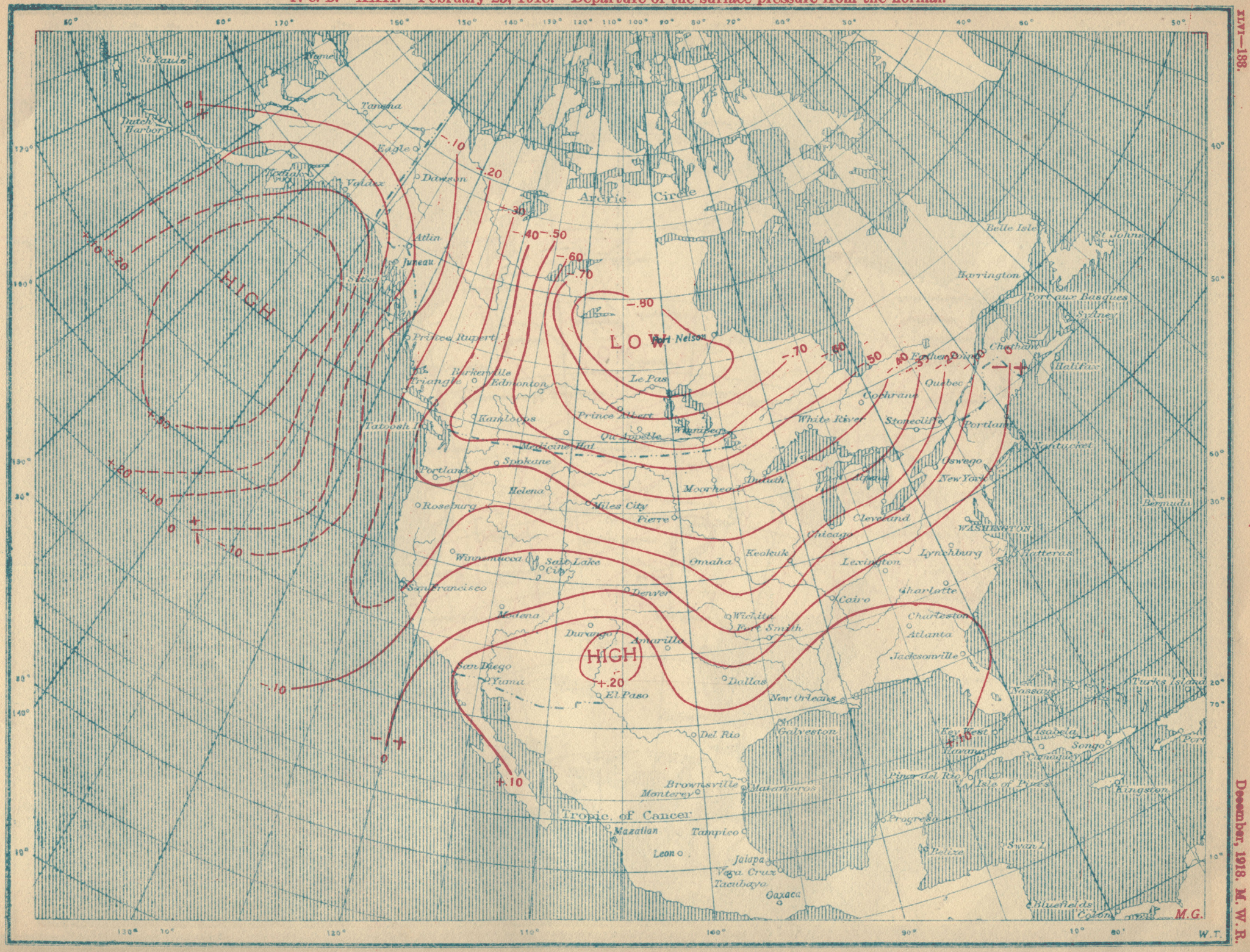


P. C. D. XX.—February 10, 1918. Departure of the surface pressure from the normal.





P. C. D. XXI.—February 15, 1918. Departure of the surface pressure from the normal.


HIGH
LOW
HIGH
Arctic Circle
Tropic of Cancer
-.10
-.20
-.30
-.40
-.50
-.60
-.70
-.80
+.10
+.20
+.30
0
St Paul
Nome
Tanana
Dutch Harbor
Eagle
Dawson
Yakutat
Atlin
Juneau
Sitka
Prince Rupert
Port Nelson
Le Pas
Edmonton
Prince Albert
Winnipeg
Qu'Appelle
Medicine Hat
Kamloops
Tatoosh I.
Portland
Spokane
Helena
Roseburg
Miles City
Pierre
Moorhead
Duluth
Minneapolis
Omaha
Keokuk
Chicago
Cleveland
New York
Oswego
Portland
Stonecliffe
White River
Cochrane
Quebec
Father Point
Chatham
Halifax
Nantucket
Bermuda
Belle Isle
St Johns
Harrington
Port aux Basques
Sydney
WASHINGTON
Hatteras
Lynchburg
Lexington
Charlotte
Charleston
Atlanta
Jacksonville
Nassau
Turks Island
Key West
Havana
Isabella
Songo
Cienfuegos
Pinar del Rio
Isle of Pines
Kingston
Progreso
Swan I.
Belize
Bluefields
Colon
Wa Wa
Winnemucca
Salt Lake City
San Francisco
Denver
Cairo
Wichita
Fort Smith
Amarillo
Durango
Medena
San Diego
Yuma
El Paso
Dallas
New Orleans
Galveston
Del Rio
Brownsville
Matamoros
Monterey
Mazatlan
Tampico
Leon
Jalapa
Vera Cruz
Tacubaya
Oaxaca
M.G.
W.T.
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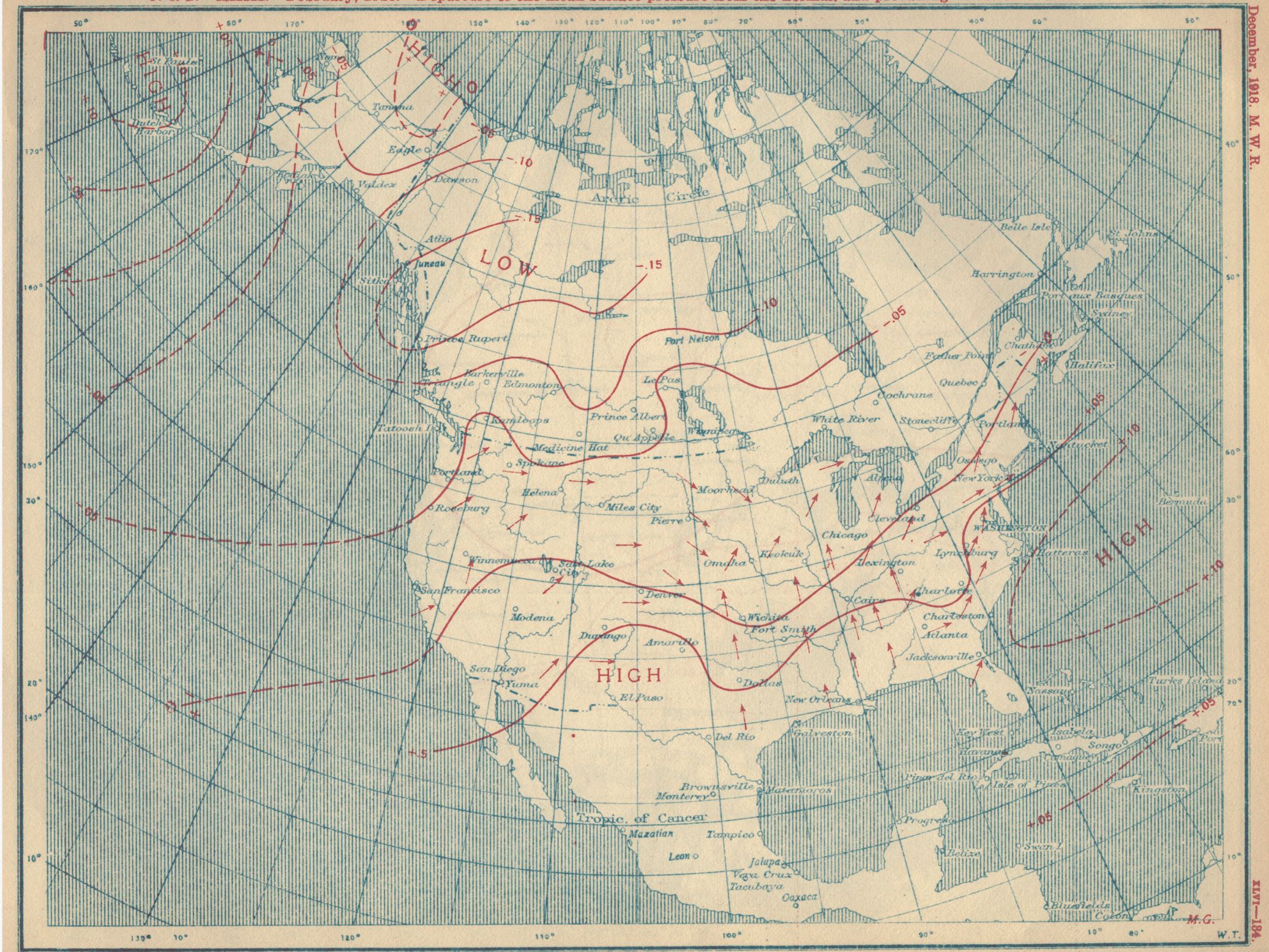
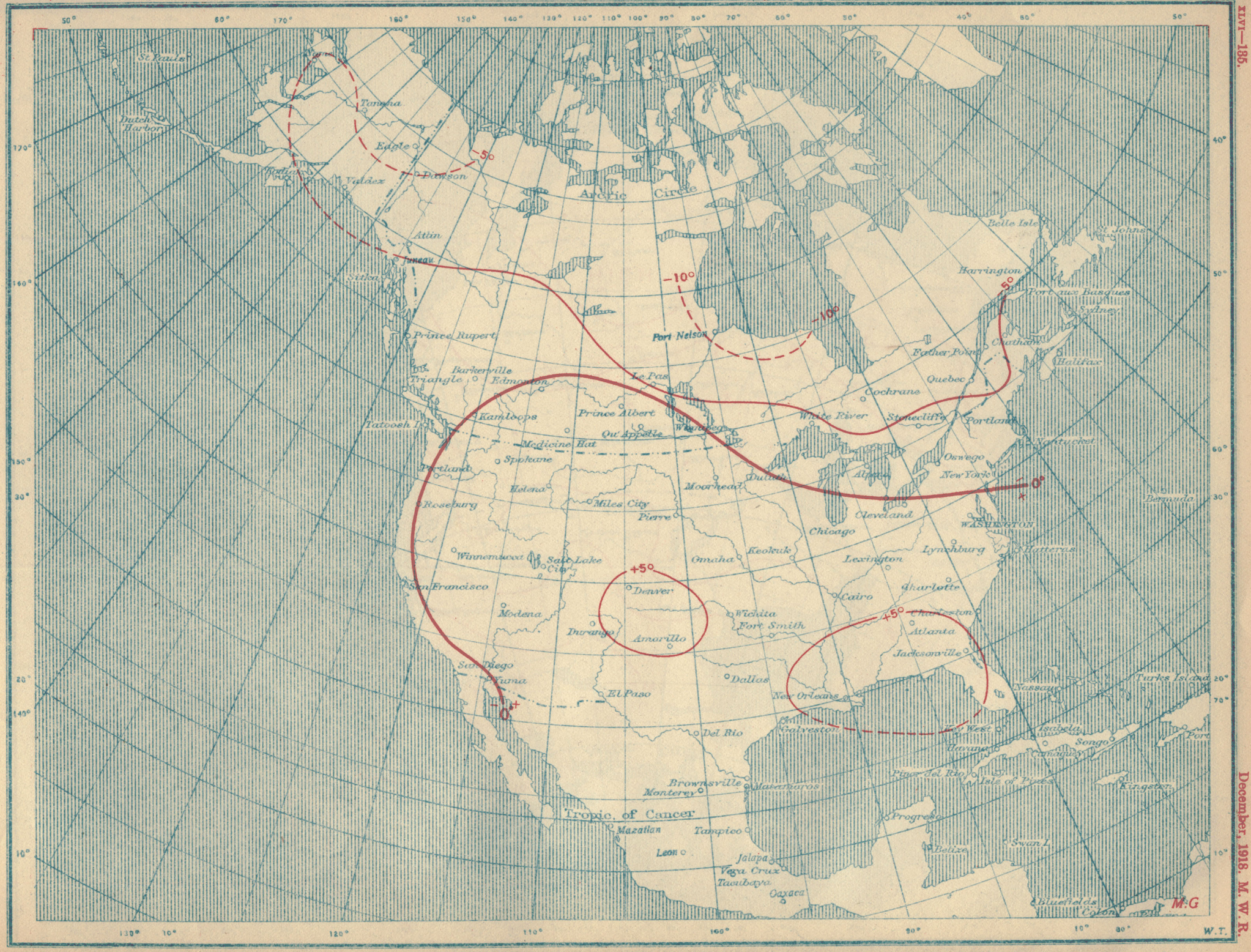
December, 1918. M. W. R.

P. C. D. XXIII.—February, 1918. Departure of the mean surface pressure from the normal, and prevailing direction of the winds.





XLVI—185.

December, 1918. M. W. R.